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Aggregate and Soil Proficiency Sample Testing Program for 2012

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Abstract	The Materials Engineering and Research Office, Soils and Aggregates Section, conducts a proficiency sample-testing program for aggregate and soil materials each year to provide a means for participating laboratories to see if they are performing satisfactorily. We also conduct a sample testing program for the tests related to Superpave consensus properties of aggregates. This is conducted along with our annual Aggregate and Soil Proficiency Sample Testing Program. The laboratories are asked to perform a number of different tests on pairs of samples that have been prepared and randomly selected at the MTO Laboratory. The samples are delivered to the participating laboratories starting in June, and they report their results starting in early August. A preliminary report issued in the first week of September allows the laboratories to examine their procedures or equipment and correct any problems that may have occurred. This is the final report for both the Aggregate and Soil Proficiency Samples and Superpave Consensus Property Testing for 2012. This year, two hundred and twenty-seven participants from the private and public sector participated in the Aggregate and Soil Proficiency Sample Testing Program. Sixty-six laboratories from the private sector and MTO Downsview laboratory reported results for all four of the Superpave consensus property tests. Results of the aggregate and soil tests from the 2012 program are found to be consistent with the results reported in the last three years, but, in some of the tests, the multi-laboratory variations show noticeable improvements over the ASTM or MTO precision estimates where available. Although there is improvement in the results, strong laboratory biases still remain in many of the test procedures. We expect that the mandatory Laboratory Quality System implemented by CCIL and their lab inspection process will bring about improvements in multi-laboratory variation.
Key Words	Aggregate, consensus property, correlation, laboratory, proficiency testing, soil, Superpave
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Executive Summary

The Soils and Aggregates Section of the Materials Engineering and Research Office runs an annual proficiency sample testing program for aggregate and soil tests. This program provides a means for participating laboratories to see if they are performing satisfactorily. The laboratories are asked to perform a number of different tests on randomly selected pairs of samples that have been prepared by the MTO Soils and Aggregates Laboratory. The samples are delivered to the participating laboratories starting in June and the laboratories are required to report their results by the second week of August. A preliminary report issued in early September gives feedback to the participants while they are still operational in the current year. This allows them to examine their procedures or equipment and correct any problems that may exist. A final report is issued after analysis of the data has been completed.

This is the final report for the 2012 MTO Aggregate and Soil Proficiency Sample Testing and the Superpave Aggregate Consensus Property Testing Programs. Proficiency test samples in duplicates were shipped to two hundred and thirty-three private and public sector laboratories. Two hundred and twenty-seven of the laboratories that requested samples submitted test results in 2012. Of these, one hundred and forty-eight were aggregate producers' and road builders' Quality Control (QC) laboratories. The remainder were engineering testing consultants' and owners' laboratories. Participation in this program is mandatory for laboratories conducting quality assurance (QA) and referee testing work for MTO contracts. However, participation is optional for laboratories that do quality control (QC) testing for contractors. In general, contractor and supplier laboratories are conducting particle size analysis, wash pass 75 μm, percent crushed particles, percent asphalt coated particles, percent flat and elongated and density tests for granular base and sub-base aggregates.

In 2012, seventy-two laboratories reported results for one or more of the tests related to Superpave aggregate consensus properties. The laboratories that participate in this program conduct uncompacted void content of fine aggregate, sand equivalent value of fine aggregate, percent of fractured particles in coarse aggregate, and percent flat particles, elongated particles, or flat and elongated particles in coarse aggregate tests, in accordance with the ASTM/AASHTO test methods.

Reports to individual laboratories contain ratings for each test method, which are based on the standardized deviate for that test (i.e. a rating of 5 for data within 1.0 standard deviation of the mean, a rating of 0 for data 3.0 or more standard deviations from the mean). Ratings of each test method are also used to calculate an overall laboratory rating for each category of tests. This rating system has acted as an incentive for laboratories to improve their performance. The rating is also used as a guide by MTO to select laboratories for its quality assurance testing and for qualifying referee laboratories.

Results of the aggregate and soil tests from the 2012 program are found to be consistent with the results from previous years and, in some of these tests, the multi-laboratory variations show noticeable improvements over the precision estimates published by AASHTO, MTO, or ASTM. Particularly, magnesium sulphate soundness, percent flat and elongated particles of coarse aggregates, Micro-Deval abrasion of fine aggregates show improvements over the precision estimates published by ASTM or MTO. Although the precision of most of the test methods compares favourably in relation to the results of previous studies and the precision estimates where available, strong laboratory biases still remain in some of the test methods. The variations in soil test results show improvement and are lower than the values reported in the previous three years of study, but the scatter plots show a strong laboratory bias.

The results of Superpave consensus property tests from the 2012 program also compare favourably with the past performance of the laboratories. The variations of two of the tests in the program were found to be lower than that of the values reported in the past three years and the values published in ASTM precision statements. The scatter diagrams for the Superpave tests also show strong laboratory biases.

The Soils and Aggregates Section continues to carry out the inspection of laboratories providing soil testing services to the ministry. This inspection is being done at the request of laboratories. The laboratories that are inspected and accepted by MTO must request a re-inspection whenever technicians or equipment change. To date, forty-four laboratories have been inspected. Thirty-seven of these laboratories are on the MTO Vendors List to do testing of soils for MTO work.

1. Introduction

This is the final report of the 2012 interlaboratory testing program organized by MTO for aggregate and soil test methods. It is primarily intended to provide a means for laboratories used by MTO to see if they are performing satisfactorily and to qualify these laboratories to perform quality assurance and referee testing for MTO contracts[1]. The design of the testing program is based on procedures for determining the precision and variability of test methods. Interested readers should refer to ASTM C670[2], C802[3], E177[4], and E178[5] for further information on interlaboratory testing programs.

Proficiency test samples were distributed to two hundred and thirty-three participants from the private and public sector laboratories. A total of two hundred and twenty-seven laboratories reported results for the Aggregate and Soil Proficiency Sample Testing Program conducted in the summer of 2012. The participants were also asked to submit results for Superpave aggregate consensus property tests, if they were equipped to perform those tests. Sixty-seven laboratories submitted results for all of the tests related to the consensus properties. Participants in both testing programs included the MTO laboratory in Downsview, the remainder being from the private sector (contractors, aggregate producers, and engineering consultants), and municipalities. Samples were delivered to laboratories in early June. A preliminary report was issued to the participants in early September.

Reports to individual laboratories contain ratings for each test method, which are based on the standardized deviate for that test (i.e. a rating of 5 for data within 1.0 standard deviation of the mean, a rating of 0 for data 3.0 or more standard deviations from the mean). Ratings of each test method are also used to calculate an overall laboratory rating. This rating system has acted as an incentive for laboratories to improve their performance.

The computer program that was developed by MTO to handle the computation and presentation of test data has two statistical methods, namely the Critical Value Method and the Iterative (Jackknife) Technique, to detect outlying observations or outliers in a set of data. For details of the program, refer to the User's Manual (report MERO-013) by Vasavithasan and Rutter, 2004. A number of statistical methods are available to test the hypothesis that the suspect observations are not outliers, but the MTO study follows the Critical Value Method recommended in Section 4 of ASTM E178. The critical value method and iterative techniques are based on two different statistical approaches. As a result, the confidence intervals yielded by these two methods differ widely depending on the number of observations (number of laboratories participating in a particular test method) and the distribution of data.

1 Laboratories must also be inspected and recognized by the Canadian Council of Independent Laboratories (CCIL).
2 ASTM C670 Practice for Preparing Precision and Bias Statements for Test Methods of Construction Materials.
3 ASTM C802 Practice for Conducting an Inter-laboratory Test Program to Determine the Precision of Test Methods of Construction Materials.
4 ASTM E177 Practice for Use of Terms Precision and Bias in ASTM Test Methods.
5 ASTM E178 Practice for Dealing with Outlying Observations.

The critical value used in this study is that value of the sample criterion, which would be exceeded by chance with some specified probability (significance level) on the assumption that all observations in the sample come from the same normally distributed population. The critical values provided in ASTM E178, Table 1 are limited to 147 observations, but over 200 laboratories participate in our annual testing program. The critical values that are being used for the MTO study were calculated at five percent significance level (Grubbs' test) based on Grubbs' (1969 and 1972) recommendations for identifying outliers. The Jackknife method recommended by Manchester (1979) is used where the strict application of the critical value method tends to include results that may not stand the best chance of representing the testing performed in conformance with each of the test methods.

2. Test Results

2.1 TABLE OF TEST RESULTS

Each participant receives an individual summary of results for their laboratory. An example of a typical report is shown in Tables 1, 2, 3, and 4. Each Table of Results identifies the laboratory by number and compares the laboratory's data with the means obtained after statistical analysis of the data received from all laboratories. The identity of the laboratories is kept confidential.

Column 1 gives the test method as designated in the MTO Laboratory Testing Manual.

Columns 2 and 3 show the test data submitted by the laboratory for a pair of samples.

Columns 4 and 5 show the mean (average) test value for each sample after removal of outliers and/or invalid test results from the data set for all laboratories performing the test.

Columns 6 and 7 list the standardized deviate for each test result. The standardized deviate is used to show how the individual test results compare to the mean. It is obtained by subtracting the mean of all data ($\overline{X}$) from the actual test result reported by the laboratory (X_i) and dividing by the standard deviation (s). That is:

$$\text{Standardized Deviate} = \frac{\left(X_i - \overline{X}\right)}{s}$$

If the test result is less than the mean, the standardized deviate is negative and, if the test result is greater than the mean, the standardized deviate is positive. In brief, the standardized deviate tells us how many standard deviations the test result is away from the mean.

Columns 8 and 9 list the test method ratings, which are similar to the standardized deviate, but are in a simple numeric form. Ratings are determined as follows:

Rating 5 - data within 1.0 standard deviation of the mean.
Rating 4 - data within 1.5 standard deviations of the mean.
Rating 3 - data within 2.0 standard deviations of the mean.
Rating 2 - data within 2.5 standard deviations of the mean.
Rating 1 - data within 3.0 standard deviations of the mean.
Rating 0 - data 3.0 or more standard deviations from the mean or data considered to be outlying by other methods.

A negative sign simply indicates a result that is smaller than the mean. If one of the paired test results for a given test is excluded based on the outlier criteria, the other test result is still subjected to the statistical analysis and is only excluded if it also fails to meet the criteria.

An outlying observation is one that appears to deviate markedly from the sample population. It may be merely an extreme manifestation of the random variability inherent in the data, or may be the result of gross deviation from the prescribed experimental procedure, calculation

errors, or errors in reporting data. The outlier criteria employed for exclusion of test results from the analysis will depend on the distribution of data and the number of participants in a test. The iterative technique is one of the methods employed in this study for the selection of outliers, and is used where the strict application of critical value method tends to include the data that does not belong to the population. In the critical value method, the standardized deviate of a lab result is compared with the critical value corresponding to the number of participants in that particular test for rejecting an outlier. The critical value is greater than 3 when the number of participants in a particular test method is 30 or more. For this reason, results with more than 3 standardized deviates may not have been identified as an outlier unless it is higher than the critical value, but a zero rating is nevertheless assigned for the test result in question. For example, if the computed standardized deviate for a lab result is 3.236 and the critical value corresponding to the number of participants in that particular test is 3.427, the lab will not be identified as an outlier but a zero rating will be assigned.

Significance need not necessarily be attached to a single low rating. However, a continuing tendency to get low ratings on several pairs of samples or on a series of tests from one procedure (e.g. sieve analysis) should lead a laboratory to re-examine its equipment and test procedure. A laboratory that reports data for a specific test consistently lower or higher than the mean over a number of test periods also needs to re-examine their test procedure, because this is evidence of a systematic bias in how the laboratory conducts the procedure. Any computer program that is used by a laboratory to calculate test results should be verified as part of this examination.

2.2 SCATTER DIAGRAMS

Youden scatter diagrams are supplied with this report (see Appendices D1 and D2). A laboratory can locate itself on the diagrams by plotting its test value for the first sample (1.12) on the horizontal axis, against its test value for the second sample (2.12) on the vertical axis. The horizontal and vertical axes are of equal length and are scaled to give the most informative display of the plotted points. In some cases, the outlying results plot outside the boundaries of the diagram. If the results from two or more laboratories happen to coincide, a single point is plotted.

Below each scatter diagram, the test number and title are given, followed by a table of statistical calculations for both samples. Here the mean, median, and standard deviation for each sample are given. The number of laboratories reporting valid data and the laboratories eliminated by statistical analysis are also listed.

The vertical and horizontal crosshairs on the plots represent the mean values for all the valid results on the first sample (1.12) and the second sample (2.12), respectively. These lines divide the diagram into four quadrants, numbered 1 through 4, beginning in the upper right-hand quadrant and continuing clockwise. In an ideal situation where only random errors occur, the points are expected to be equally numerous in all quadrants and will form a circular distribution. This follows because plus and minus errors should be equally likely. Often, however, the points tend to concentrate in quadrants 1 and 3 on the diagram. This occurs because laboratories tend to get high or low results on both samples. This gives evidence of individual laboratory biases. As the tendency to laboratory bias increases, the

departure from the expected circular distribution of points towards a linear distribution from quadrant 1 to 3 occurs. Such a distribution of points indicates systematic variation. Figure 1 gives examples of scatter diagrams.

Table 1. Summary of Results for Laboratory 47

TEST RESULTS FOR LABORATORY NUMBER 47			DATE PREPARED: November 15, 2012					
COARSE AGGREGATE REFERENCE SAMPLES 1.12 & 2.12								
TEST METHOD	LABORATORY DATA		MEAN OF LABORATORIES		STANDARDIZED DEVIATE		LAB RATING	
	1.12	2.12	1	2	1	2	1	2
LS-601 Wash Pass 75 μm (Coarse Agg.)	2.530	2.410	2.395	2.256	0.442	0.487	5	5
LS-602 – Coarse Aggregate								
Percent Passing 19.0 mm	96.900	92.800	95.059	93.726	1.855	-0.853	3	-5
Percent Passing 16.0 mm	92.900	87.000	90.163	87.640	1.678	-0.397	3	-5
Percent Passing 13.2 mm	88.300	82.500	85.363	82.006	1.513	0.268	3	5
Percent Passing 9.5 mm	78.300	71.300	75.786	71.506	1.110	-0.091	4	-5
Percent Passing 4.75 mm	61.090	53.600	58.115	53.832	1.278	-0.106	4	-5
LS-603 Los Angeles Abrasion, %	20.000	20.100	22.645	21.873	-2.006	-1.318	-2	-4
LS-607 Percent Crushed Particles	81.900	82.400	76.931	77.495	0.891	0.831	5	5
LS-608 % Flat & Elongated Particles	1.700	1.500	3.672	3.614	-1.096	-1.138	-4	-4
LS-609 Petrographic Number (Concrete)	145.00	129.00	131.4	127.7	0.89	0.13	5	5
LS-614 Freeze-Thaw Loss, %	13.000	11.600	10.109	9.772	1.026	0.608	4	5
LS-618 Micro-Deval Abrasion Loss (CA)	18.200	19.500	19.169	19.112	-0.847	0.423	-5	5
LS-620 Accelerated Mortar Bar (14 Days)								

Blank spaces represent not tested.
Bold and Underline * - Calculation considered outlier
∩ - Outliers by Manual Deletion

Table 2. Summary of Results for Laboratory 47

TEST RESULTS FOR LABORATORY NUMBER 47			DATE PREPARED: November 15, 2012					
FINE AGGREGATE REFERENCE SAMPLES 1.12 & 2.12								
TEST METHOD	LABORATORY DATA		MEAN OF LABORATORIES		STANDARDIZED DEVIATE		LAB RATING	
	1.12	2.12	1	2	1	2	1	2
LS-623								
Maximum Wet Density (g/cm^3)	2.418	2.407	2.416	2.421	0.069	-0.434	5	-5
Maximum Dry Density (g/cm^3)	2.260	2.250	2.257	2.264	0.074	-0.401	5	-5
Optimum Moisture, %	7.000	7.000	7.126	7.066	-0.383	-0.203	-5	-5
LS-604 – Coarse Aggregate								
Relative Density (O.D.)	2.659	2.662	2.655	2.657	0.511	0.587	5	5
Absorption	2.070	2.050	2.094	2.063	-0.198	-0.095	-5	-5
LS-621								
Asphalt Coated Particles, %	52.600	51.300	47.132	47.634	1.019	0.699	4	5

Blank spaces represent not tested.
Bold and Underline * - Calculation considered outlier
∩ - Outliers by Manual Deletion

Table 3. Summary of Results for Laboratory 47

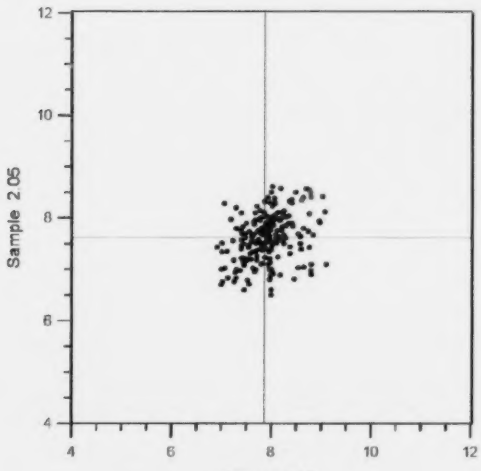
TEST RESULTS FOR LABORATORY NUMBER 47			DATE PREPARED: November 15, 2012					
FINE AGGREGATE REFERENCE SAMPLES 3.12 & 4.12								
TEST METHOD	LABORATORY DATA		MEAN OF LABORATORIES		STANDARDIZED DEVIATE		LAB RATING	
	3.12	4.12	3	4	3	4	3	4
LS-605 – Fine Aggregate								
Relative Density (O.D.)	2.653	2.648	2.647	2.649	0.559	-0.104	5	-5
Absorption	0.990	1.060	1.171	1.148	-1.168	-0.536	-4	-5
LS-606 – Coarse Aggregate								
$MgSO_4$ Soundness Loss, %	17.800	18.900	26.090	25.295	-1.539	-1.207	-3	-4
LS-606 – Fine Aggregate								
$MgSO_4$ Soundness Loss, %								
LS-619 – Fine Aggregate								
Micro-Deval Abrasion	17.200	17.400	17.628	17.737	-0.403	-0.314	-5	-5
LS-602 – Fine Aggregate								
Percent Passing 2.36 mm	43.600	41.300	43.215	40.324	0.155	0.430	5	5
Percent Passing 1.18 mm	30.300	30.300	30.203	28.488	0.044	0.863	5	5
Percent Passing 600 µm	22.100	22.300	22.014	21.015	0.054	0.738	5	5
Percent Passing 300 µm	17.000	17.000	16.500	15.951	0.405	0.869	5	5
Percent Passing 150 µm	12.900	13.000	12.346	11.951	0.693	1.277	5	4
Percent Passing 75 µm	9.560	9.590	9.122	8.823	0.708	1.270	5	4

Blank spaces represent not tested.
Bold and Underline * - Calculation considered outlier
∩ - Outliers by Manual Deletion

Table 4. Summary of Results for Laboratory 47

TEST RESULTS FOR LABORATORY NUMBER 47			DATE PREPARED: November 15, 2012					
SOILS REFERENCE SAMPLES 5.12 & 6.12								
TEST METHOD	LABORATORY DATA		MEAN OF LABORATORIES		STANDARDIZED DEVIATE		LAB RATING	
	5.12	6.12	1	2	1	2	1	2
LS-702 – Sieve Analysis of Soil								
Percent Passing 2.00 mm	100.00	100.00	99.996	99.999	0.155	0.114		
Percent Passing 425 μm	100.00	100.00	99.793	99.784	1.185	1.164	4	4
Percent Passing 75 μm	99.800	99.800	99.103	99.100	2.034	2.075	2	2
Percent Passing 20 μm	**68.300**	**68.800**	**80.643**	**80.639**	* **-2.911**	* **-2.989**	**0**	**0**
Percent Passing 5 μm	39.300	**31.800**	43.736	**43.899**	-1.618	* **-4.740**	-3	**0**
Percent Passing 2 μm	24.300	22.800	28.569	28.833	-1.832	-2.603	-3	-1
LS-703								
Liquid Limit, %	32.100	32.100	32.167	32.158	-0.058	-0.050	-5	-5
LS-704								
Plastic Limit, %	19.600	19.700	18.951	18.877	0.589	0.740	5	5
Plasticity Index, %	12.500	12.400	13.288	13.415	-0.464	-0.590	-5	-5
LS-705								
Specific Gravity of Soil	2.740	2.715	2.721	2.718	0.853	-0.132	5	-5
AGGREGATE CONSENSUS PROPERTIES								
Uncompacted Void Content	44.700	44.300	44.044	44.057	0.998	0.386	5	5
Sand Equivalent Value	38.400	36.900	32.519	31.959	1.625	1.347	3	4
Percent Fractured Particles	84.700	87.300	78.499	78.818	1.143	1.326	4	4
% Flat & Elongated Particles	0.500	0.100	0.664	0.551	-0.357	-1.428	-5	-4

Blank spaces represent not tested.
Bold and Underline * - Calculation considered outlier
∩ - Outliers by Manual Deletion

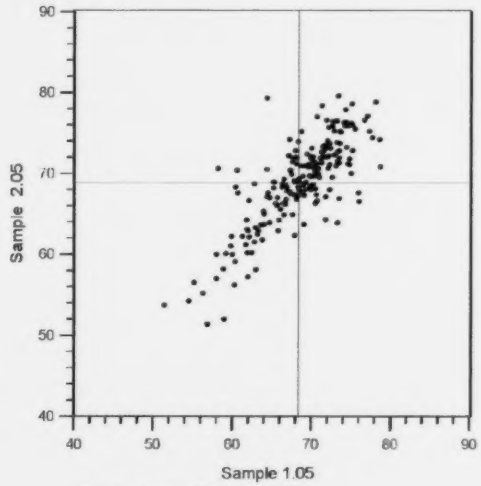


Test 25: Percent Passing the 75 um Sieve

	Mat 1	Mat 2
Mean	7.930	7.630
Median	7.800	7.500
Std Dev	0.460	0.470
n = 203		

Labs Eliminated: 447, 497, 452, 518

Scatter diagram for a test showing random variation with little laboratory bias

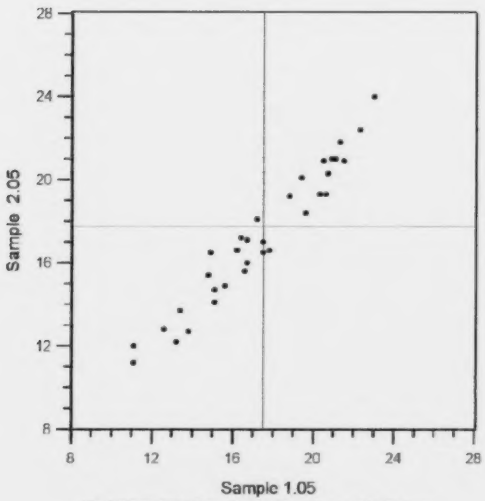


Test 12: Percent Crushed Particles

	Mat 1	Mat 2
Mean	68.491	68.905
Median	68.300	64.500
Std Dev	5.054	5.402
n = 201		

Labs Eliminated: 345, 350, 436, 480

Scatter diagram for a test showing a combination of random variation and laboratory bias for some laboratories

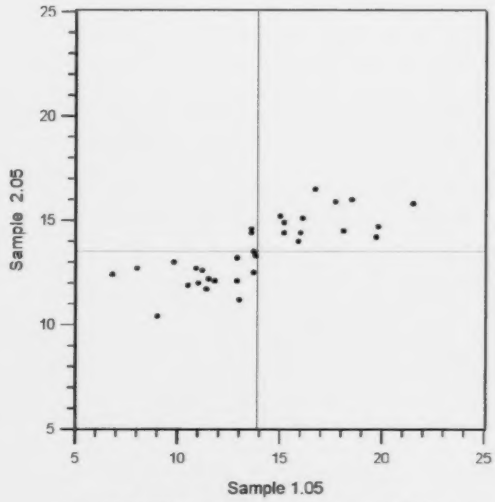


Test 29: MgSO4 Soundness (Fine Aggregate), % Loss

	Mat 1	Mat 2
Mean	17.370	17.258
Median	15.800	15.600
Std Dev	3.276	3.325
n = 32		

Lab Eliminated: None

Scatter diagram for a test showing pronounced between laboratory bias and equal variation for each material



Test 11: MgSO4 Soundness (Coarse Aggregate), % Loss

	Mat 1	Mat 2
Mean	13.890	13.570
Median	12.900	13.600
Std Dev	3.533	1.541
n = 31		

Lab Eliminated: None

Scatter diagram for a test with pronounced between laboratory bias but unequal variation for each material

Figure 1. Examples of Scatter Diagrams

2.3 OUTLIERS

In dealing with suspected outlying observations or 'outliers', our purpose is to remove those observations that do not belong to the sample population and to provide some statistical criteria for doing so. There are a number of ways to do this. In most of these, as ASTM E178 states, 'the doubtful observation is included in the calculation of the numerical criterion (or statistic), which is then compared with a critical value based on the theory of random sampling to determine whether the doubtful observation is to be retained or rejected.' The critical value is that value of the sample criterion that would be exceeded by chance with some specified (small) probability on the assumption that all observations did indeed constitute a random sample from a common system of causes, a single parent population, distribution, or universe.

The MTO study follows the criteria recommended for single samples in Section 4 of ASTM E178 for rejecting the doubtful observations at the ninety-five percent confidence level. The critical value method is based on the assumption of normality, and the critical values are calculated using Student's T distribution. The assumption in this method is that all of the observations come from the same normal population. The doubtful observation is included in the calculation of mean and standard deviation of the population. Then the critical value, T_n, for that observation, n, in question is calculated and compared with the critical value based on the theory of random sampling. The doubtful observation is rejected if T_n is higher than the critical value for the five percent significance level. The outlier is removed from the data set and the iterations are continued until no outliers are detected, and a revised mean and standard deviation are calculated after deleting the outlier. The ratings of the laboratories are determined based on the revised mean, standard deviation, and standardized deviate.

In some cases, the strict application of the critical value method tends to include laboratories in the population that report extraneous results. These results may not represent testing performed in conformance with the test method. In those cases, the application of the iterative technique (Manchester[6]) is used. The Constant C in the iterative technique is computed using Fisher's F distribution, and it depends on the number of participating laboratories in a particular test. In this technique, an outlying observation is rejected based on a statistical criterion, but the confidence interval may vary depending on the number of participants and the distribution of sample population.

In the iterative technique, after screening the test results for any errors, the doubtful test result is included in the calculation of mean and standard deviation of the data set. The absolute residual values (actual test result minus the mean) are then computed and test result farthest from the mean by a unit of Cs (standard deviation, s, multiplied by a constant C) is identified as an outlier. One outlier at a time is identified and rejected in a manner similar to that of critical value method.

6 The Development of an Interlaboratory Testing Program for Construction Aggregates, by L. Manchester, Ministry of Transportation, Ontario, Engineering Materials Office Report EM-33, Downsview, December, 1979.

Three of the test methods included in this proficiency sample testing program requires reporting of control sample results to demonstrate that the testing process of the laboratory is in control. The laboratories that report control sample results outside the range of values established for the material are identified during the screening of test results for any errors. These laboratories are manually removed from the data set during the analysis and considered as outliers.

3. Discussion

The following discussion contains general and test-specific comments for the 2012 test period. Where ASTM, AASHTO or MTO precision statements are published for a given test, an attempt has been made to compare these with the statistics for this period.

A discussion of statistical techniques is presented in the Glossary of Terms, found in Appendix A.

3.1 NOTES ON MATERIAL SOURCES

Materials used in this test period were as follows:

- Coarse and fine aggregate tests, including Sieve Analysis, Percent Crushed Particles, Moisture Density Relationship, Relative Density and Absorption (FA), Micro-Deval Abrasion Loss (FA), Uncompacted Void Content, Sand Equivalent Value, and Percent Fractured Particles – Granular A (OPSS 1010) from Drain Brother's, Norwood Pit (MTO MAIDB No. C01-064).
- Coarse aggregate tests, including Wash Pass 75 μm, Percent Flat and Elongated Particles, Petrographic Analysis (CA), Relative Density and Absorption (CA), Los Angeles Abrasion, Micro-Deval Abrasion Loss (CA), Freeze-Thaw Loss, Magnesium Sulphate Soundness (CA), and Percent Flat, Elongated, or Flat and Elongated Particles – HL-stone (OPSS 1003) from Waterford Sand and Gravel, Vinemount Quarry (MTO MAIDB No. G08-011).
- Fine Aggregate Petrographic Examination - sand from Lafarge Fonthill Pit (MTO MAIDB No. N03-026).
- Soil tests – Lake St. Clair Clay Plain clay from Dresden, Chatham (MTO MAIDB No. W02-027).

3.2 NOTES ON SAMPLE PREPARATION

The material processed for the coarse and fine aggregate tests conforms approximately to the gradation requirements of Granular A. Bulk samples were prepared using a large spinning riffler, developed and built by staff at the MTO Downsview Laboratory (refer to Figures 2 and 3 of Report MI-179, February 2000). The use of a spinning riffler ensures that, as far as possible, each sample is identical to every other sample. It has been found that this is the best technique for minimizing sample bias. A bobcat loader was used to fill an aggregate bin from the stockpile and the material was fed along a conveyor belt to fill 33 identical bags (fitted with funnels) on a spinning turntable. It was found that about 20 revolutions of the turntable were required to fill each bucket to 23 ± 2 kg of Granular A. This resulted in more homogeneity of the samples than would normally be the case using other techniques. In total, six hundred and fifty 23 ± 2 kg samples were prepared for the tests on Granular A, and randomized for distribution to participating laboratories. The participants were responsible for the preparation of their own fine aggregate samples (3.12 and 4.12) from the two bags of

Granular A supplied.

In addition to Granular A, additional samples consisting of material with approximately 95% retained on 4.75 mm sieve was also supplied for tests that require coarse aggregates. The number of revolutions of the turntable required for coarse aggregate to fill each bucket to approximately 28 ± 2 kg was found to be about 25 revolutions of the turntable. In total, six hundred and fifty 28 ± 2 kg samples were prepared for the coarse aggregate tests, and randomized for distribution to participating laboratories.

Soil material was air-dried, processed to pass through a 2.0 mm sieve using a Fritsch Soil Mill Pulverizer, and placed in 20 kg buckets. Individual scoops were collected from each bucket and placed in a separate container. The material from the container was then transferred to the hopper of a small spinning riffle splitter. The hopper of the spinning riffler used is capable of filling 24 identical 2 kg containers per run. This method was used to create uniform 20 kg buckets. The correlation material was then prepared by obtaining representative samples from a 20 kg bucket. The material collected from the 20 kg bucket was then transferred to the hopper of the small spinning riffler and the 500 g correlation samples were prepared. The samples were then randomized for distribution to participating laboratories.

3.3 NOTES ON INDIVIDUAL TESTS

For each test, comments have been made pertaining to the variation illustrated by the associated scatter diagram shown in Appendix D. The technique used to test for outliers is stated and, where possible, reasons for the outlying observations are offered. It is important to keep in mind that there are many variables influencing laboratory testing.

A summary of the statistical data is presented in the Multi-Laboratory Precision Tables found in Appendix C. Besides the comparison made to ASTM, AASHTO or MTO precision statements, comparison of the variation between previous test periods is made for each of the tests. Because the materials usually differ from year to year, it is emphasized that the comparison between years should be used only as a guide. It is important to note that the yearly use of different materials will have some effect on the variation exhibited in some tests, while it will have relatively little effect on others. For example, the magnesium sulphate soundness test normally exhibits increased variation as higher mean loss is reported. A coarse aggregate sample having an average mean loss of twenty percent would likely show more variation than a coarse aggregate sample having an average mean loss of ten percent. On the other hand, a sieve analysis could be performed on those same two aggregates, with the percent passing each sieve and the variation being remarkably similar for the two samples.

3.4 PROFICIENCY SAMPLE TESTS

3.4.1 LS-601 - Wash Pass 75 µm (Coarse Aggregate) – Test No. 1

Two hundred and seventeen laboratories reported results for this test in 2012. Eighteen outliers were identified and rejected using the iterative technique. The standard deviations of 0.31 and 0.32 obtained in 2012 are noticeably higher than the values that were reported in the past three years and the multi-laboratory variation of 0.19 published in the latest revision (No. 27) of LS-601 for aggregates with less than 2.0% material passing the 75 µm sieve. The multi-laboratory variations obtained in 2012 is also found to be higher than the value of 0.22 published by ASTM C 117 for aggregates with less than 1.5% material passing the 75 µm sieve. The mean value of the aggregate used in 2012 consisted of approximately 2.3% material finer than 75 µm, which is slightly higher than the range of values for which the ASTM and MTO precision statements were established. However, coefficient of variation of 13.5% obtained in 2012 is significantly lower than the values of 34.2% and 26% reported in 2010 and 2011, respectively. The scatter diagram provided in the Appendix D1 shows a combination of random variation and laboratory bias for some laboratories. The laboratories that are identified as outliers should examine their test procedure more closely, especially the achievement of constant dry mass at the beginning and end of the test.

3.4.2 LS-602 - Sieve Analysis (Coarse Aggregate) – Test Nos. 2 to 6

These tests represent the coarse aggregate portion of the Granular A sample gradation. Tests 20-25 carried out on the material passing 4.75 mm sieve as prepared by the participants (samples 3.12 and 4.12) represent the remainder of the gradation. The data is presented in percent passing format and is compared to precision statements developed in the same format by Vogler and Spellenberg[7].

The Granular A samples 1.12A and 2.12A supplied for the sieve analysis test consisted of approximately 44% of the material retained on 4.75 mm sieve, and conform to the grading of Granular A materials used in the past MTO Aggregate and Soil Proficiency Sample Testing Programs. The gradings reported for Test Nos. 2-6 represent the combined gradings of coarse and fine aggregates. The proficiency test samples were prepared with the large spinning riffler described in Section 3.2.

The standard deviations obtained in 2012 for all of the sieves, with the exception of 19.0 mm and 9.5 mm sieves, are found to be consistent with the expected variations given in the ASTM C 136 precision statements. In the case of 19.0 mm and 9.5 mm sieves, the standard deviations obtained are slightly lower than that of the precision estimates published by ASTM.

Two hundred and seventeen laboratories reported results for the sieve analysis test in 2012. Outliers were eliminated using the iterative technique. Successive scatter diagrams show a

7 Vogler, R.H., Department of Transportation, Michigan, AASHTO Technical Section 1c; T27 and Spellenberg, P.A., AASHTO Materials Reference Laboratory; Unpublished Paper.

fairly uniform distribution of points about the mean (i.e. a random variation with little laboratory bias). The number of outliers identified varies from sieve to sieve, and ranges from two for the 19.0 mm sieve to a maximum of ten for 4.75 mm sieve.

Possible reasons for outlying observations include factors that impact the measurement process such as sieve condition (state of repair and cleanliness), efficiency of the sieving process and apparatus, initial sample mass, and mass on a given sieve. If your laboratory has performed poorly in this test period, you should inspect your sieves (use CAN/CGSB-8.1-88 or ASTM E11 as guides) and your sieve shaker(s) thoroughly, and, once satisfied that they are in order, perform a sieving efficiency test as described in LS-602 to pinpoint any problems.

3.4.3 LS-603 - Los Angeles Abrasion Loss (Coarse Aggregate) – Test No. 8

Only eleven laboratories reported results for this test in 2012. No outlier was detected by the use of critical value method or iterative technique. Considering the number of observations (11) used, the analysis may not yield meaningful or representative statistical data. The lower left and upper right quadrants together account for eight of the eleven points, which is evidence of significant laboratory biases. This test shows systematic variation, as was found in previous years. However, the standard deviations obtained in 2012 are consistent with the values that were reported in the past three years.

ASTM precision statements for 19.0 mm maximum size coarse aggregate, with percent loss in the range 10% to 45%, give a multi-laboratory coefficient of variation of 4.5%. Therefore, the results from two different laboratories should not differ by more than 12.7%. The mean loss of 22.3% in this test is within the range of values for which ASTM C 131 data was established. This year's coefficient of variation (average 6.0%) is slightly higher than that of the value, 4.5%, given in the ASTM precision statements.

3.4.4 LS-604 - Relative Density of Coarse Aggregate – Test No. 9 and Absorption of Coarse Aggregate – Test No. 10

LS-604 follows the procedures described in ASTM C 127-12 for the determination of relative density (Test No. 9) and absorption property (Test No. 10) of coarse aggregates. ASTM C 127 provides precision statements for relative density but the statements do not include precision estimates for the absorption property. In the case of LS-604, the latest revision (No. 27) provides precision estimates for both relative density and absorption of coarse aggregates with absorption properties less than 2.0%. Precision statements for LS-604 were established based on the data gathered through the MTO proficiency sample testing program conducted for the past twelve years.

One hundred and five laboratories reported results for these tests in 2012. Three laboratories in both relative density and absorption were identified as outliers using the iterative technique. The standard deviation of 0.008 obtained for bulk relative density in 2012 is slightly higher than the values that were reported in the past three years as well as the precision estimate of 0.006 published in the LS-604. However, the variation in 2012 is considerably lower than the value of 0.013 published in ASTM C 127. In the case of

absorption test, the standard deviations of 0.12 and 0.13 obtained this year are slightly higher than the precision estimate of 0.09 provided in the LS-604. However, the coefficient of variation of 6.1% obtained this year is considerably lower than the range of values (8.4% to 15.3%) reported in the past three years studies. The scatter diagrams for both Test Nos. 9 and 10 show a combination of random variation and laboratory bias for some laboratories.

3.4.5 LS-606 - Magnesium Sulphate Soundness (CA) – Test No. 11

Forty-three laboratories reported results for this test in 2012. One outlier was identified by the use of critical value method. The scatter diagram shows a strong laboratory bias and all the points, with the exception of eight (18%), are accounted in the lower left and upper right quadrants. This test has historically shown high coefficients of variation due to the difficulty of maintaining solution of the correct density and insufficient drying by some laboratories. The average mean of 25.7% in this test is higher than the range of values (9% to 20%) for which the ASTM C 88 precision estimate was established. The coefficient of variation of 20.8% obtained in 2012 is slightly higher than the value of 17% reported in the 2011 study. However, the coefficient of variation obtained in 2012 is noticeably lower than that of the value published in the ASTM precision statements. ASTM reports a multi-laboratory coefficient of variation of 25% for coarse aggregate with percent loss in the range of 9% to 20%.

3.4.6 LS-607 - Percent Crushed Particles – Test No. 12 and Percent Cemented Particles – Test No. 7

The coarse aggregate samples supplied did not contain adequate amount of material retained on the 19.0 mm sieve. For this reason, participants were advised to perform the test on coarse aggregate passing the 19.0 mm sieve only and to calculate the weighted average by assigning the same percent crushed particles value as the next smaller fraction (i.e., 19.0 mm - 13.2 mm) for 26.5 mm to 19.0 mm that need not be tested.

LS-607 was revised in April 2012 (Revision No. 27) to provide clarity for calculation of weighted average of percent crushed particles and to up date the precision statements. The participants were provided with the revised test method and asked to follow the revised guidelines provided to compute the weighted average. This year, two hundred and sixteen laboratories submitted results for this test. One lab was manually removed from the analysis and identified as an outlier for reporting incomplete test results. In addition, fourteen laboratories were selected as outliers by employing the iterative technique.

The standard deviations of 5.6 and 5.9 obtained in 2012 are slightly higher than the precision estimate of 4.7 published in the LS-607. However, the variations are consistent with the values ranging from 5.1 to 7.1 reported in the 2009 and 2010 studies, and the value of 6.0 obtained during the 1989 MTO workshop. The average mean of 77.2% in this test is within the range of values (55% to 85%) for which the MTO precision statements were established. The scatter diagram shows a random variation and operator bias for some laboratories. ASTM has a very similar test method (D 5821) but has not conducted interlaboratory studies to determine precision and currently publishes precision data (standard deviation of 5.2 for a mean percent crushed particles value of 76.0%) obtained from MTO study.

3.4.7 LS-608 - Percent Flat and Elongated Particles – Test No. 13

The determination of a flat and/or elongated particle is dependent on operator skill and judgement in using the measurement tool. The ASTM and CSA procedures use a proportional calliper device to measure the *greatest* length or width to thickness ratio. The MTO procedure previously measured the ratio of *mean* length or width to the *mean* thickness (MTO Laboratory Manual Revision 15 and earlier). The MTO procedure (Revision 16 and up) has been modified to agree with the ASTM definition. All participants should be using the latest MTO version of the test. Flat and elongated particles are defined in the MTO test method as those pieces whose greatest dimension in the longitudinal axis, compared to the least dimension in a plane perpendicular to the longitudinal axis, exceeds a ratio of 4:1. This test method is similar to that of ASTM D 4791 and uses the same definition, with the exception of ratio, for the flat and elongated particles. In ASTM, the flat and elongated particles are defined as the pieces that exceed a ratio of 3:1 or 5:1. In LS-608, the test sample is separated into number of fractions and the weighted average of percent flat and elongated particles is calculated using the result of every fraction tested. This test method was revised in April 2012 (Revision No. 27) to provide clarity for calculation of weighted average from the results of each fraction and to up date the precision statement. The participants were provided with the revised test method and asked to follow the guidelines provided in the test procedure to compute the weighted average.

The coarse aggregate samples supplied did not contain adequate amount of material retained on the 19.0 mm sieve. For this reason, participants were advised to perform the test on coarse aggregate passing the 19.0 mm sieve only and to calculate the weighted average by assigning the same percent flat and elongated particles value as the next smaller fraction (i.e., 19.0 mm - 13.2 mm) for 26.5 mm to 19.0 mm that need not be tested.

Two hundred and fourteen laboratories reported results for this test in 2012. Two laboratories were manually removed from the analysis and identified as outliers for reporting incomplete test results. Iterative technique was used to reject additional nine outliers. LS-608 provides precision estimate for coarse aggregate passing 19.0 mm and retained on 4.75 mm with percent flat and elongated particles ranging from 2.0% to 9.5%. The standard deviations of 1.8 and 1.9 obtained in 2012 are slightly higher than that of the values (1.2 and 1.3) reported in 2011. However, the multi-laboratory variations are noticeably lower than the precision estimate of 2.3 published in LS-608. In the ASTM D 4791, the precision estimates are published only for three individual fractions ranging from 19.0 mm to 4.75 mm and are based on the coefficient of variation. A direct comparison of the precision estimates from ASTM is not appropriate with that of the estimates provided in LS-608. The precision estimates published in LS-608 are on the basis of standard deviation, and was estimated from the weighted averages calculated using the results of four fractions ranging from 19.0 mm to 4.75.mm.

The scatter diagram provided in the Appendix D1 shows a combination of random variation and laboratory operator bias for some laboratories. In general, laboratories that reported values in excess of 8.5% should critically examine their equipment and procedure.

3.4.8 LS-609 - Petrographic Analysis (Coarse Aggregate) – Test No. 14

This test requires the participating laboratories to produce a petrographic number (PN) for concrete aggregate. The coarse aggregate examined in 2012 was stone from the Waterford Group's Vinemount Quarries, located 4.5 km southeast of Stoney Creek, Ontario. Vinemount Quarries extracts aggregates from the Middle Silurian Lockport Formation including the Goat Island Member with Ancaster chert beds, the Vinemount shale beds, and parts of the Eramosa Member. In general the rocks in the area of extraction consist of fine to medium crystalline dolostone, argillaceous dolostone, and inter-bedded argillaceous dolostones and shales. Chert lenses and nodules as well as gypsum and calcite nodules are common through most of the sequence.

Analysts from 36 laboratories examined samples 1.12ST and 2.12ST and submitted worksheets showing subdivision according to rock type and quality. Laboratories 59, 80 and 216 used the same analyst. Participants in this test were instructed to analyse only the material passing the 19.0 mm sieve and retained on 9.5 mm using a grading specified. Laboratories 5, 14 and 27 did not follow the instructions and included the material finer than 9.5 mm, i.e., 6.7 mm fraction, as part of their analysis. For this reason, these three laboratories were manually removed from the statistical analyses and identified as outliers. Laboratories 5 and 27 failed to report the masses of each fraction and the worksheets were found to be incomplete. Further, calculation errors in computing PN value of sample 1.12ST were noted on the worksheets submitted by Laboratories 39, 71, 102, 216, and 316. In the case of Laboratory 77, the error was noted on the worksheet for sample 2.12ST.

The samples supplied contained approximately 75% of good aggregate (consisting mostly of hard to medium hard carbonate), 22% of fair aggregate (consisting mostly of slightly shaley and soft carbonate with minor amounts of chert/cherty carbonate), 2% of poor aggregate (consisting mostly of shaley carbonate with minor amounts of chert/cherty carbonate), and 1% of deleterious aggregate (consisting mostly of shale and gypsum). There were traces of gypsum in some particles, which depending on quantity would be placed in the good category (less than 10% gypsum) or in the poor category (gypsum from 10 - 49%). Occasionally, there were also pieces of gypsum (greater than 49% of the particle area), which would be classified as deleterious.

The contents of good, fair, poor and deleterious noted above indicate that the petrographic number of this material is approximately 163. This relatively high petrographic number correlates well with the values obtained for tests such as micro-Deval, freeze-thaw and magnesium sulphate soundness.

Laboratories that reported more than 85% of good aggregate content, low amounts of slightly shaley and soft carbonate (especially if reported less than 5%) should review the examination of their samples. In addition, the laboratories that have not reported the presence of gypsum should also review their samples.
Laboratories 30, 71, 102, and 260 reported presence of conglomerate-sandstone-arkose (Types 3, 22, 30 or 46), greywacke-argillite (Types 6 and 29), gneiss-amphibolite-schist (Types 4, 25 and 50), granite-diorite-gabbro (Types 8, 27 and 51), and trap (Type 9) in the amounts of more than 1%. None of these rock types were present in the samples supplied for

2012 program. These four laboratories were rejected from the statistical analyses and identified as outliers.

It is recommended that the laboratories reporting low petrographic numbers to re-examine their samples, with particular emphasis on correct identification of soft carbonate, slightly shaley carbonate and shaley carbonate. A common reason for low petrographic numbers may be a failure to soak the samples in water for a sufficient period prior to examination as per the test method. In addition, some of the analysts failed to recognise the presence of gypsum. These analysts should also re-examine their samples to determine whether the presence of gypsum was overlooked.

In addition to the seven laboratories that were removed from the analyses manually one outlier was rejected using the critical value method. The similar ASTM standard for this test (C 295) does not report a petrographic number and has no precision statement.

3.4.9 LS-616 - Petrographic Examination (Fine Aggregate) – Test No. 15

The fine aggregate examined in 2012 was sand from the Lafarge Fonthill Pit, located on the Niagara Peninsula, 3.2 km west of Fonthill.

The Fonthill pit is located within the northwest end of a large ice contact delta and kame deposit. The sand and gravel produced is composed mainly of Silurian dolostone; Ordovician limestone, sandstone, siltstone, red Queenston Formation shale and silty shale; and igneous and metamorphic rocks and minerals derived from the Canadian Shield. Cemented particles are common, particularly in the larger particle sizes. Cement composition is typically either iron oxyhydroxide or calcium carbonate.

Analysts from 12 laboratories examined samples 1.12 and 2.12 and submitted worksheets showing subdivision according to rock/mineral type (silicate, carbonate, shale, mica, chert, contamination and cementation) and sieve size. Laboratories 59, 80 and 101 used the same analyst.

Petrographically the major constituents of sand from the Fonthill deposit are: sandstone, siltstone, shale and cemented particles, with subordinate carbonates, igneous and metamorphic rocks and minerals in the coarser fractions. The finer fractions generally contain quartz, siltstone, shale and feldspar with subordinate hornblende, garnet, zircon and mica in the finer fractions.

This sample may have been challenging for many analysts with respect to classification of silicate rock types versus carbonate rock types. This is because the dominant component of the coarser fractions was fine- to very fine-grained sandstone with calcium carbonate cement. The average grain size of the sandstone is approximately 0.1 mm, and grades locally into silty sandstone to siltstone. Shale (predominantly red in colour) is generally only a minor component of the sample (<5%). Locally the shale grades into silty shale and shaley siltstone with increasing silt content (MTO unpublished report). Carbonate is also a common cementing component within nearly all the argillaceous rock types present.

Cemented particles were correctly recognized by all laboratories, particularly where the rock type was concentrated in the passing 4.75andretained 2.36, passing 2.36 and retained 1.18, and passing 1.18 and retained 600 fractions.

Shale was also correctly recognized by almost all laboratories (0-5% reported). Where reported values of shale were relatively low or not present there was typically a corresponding increase in reported amounts of cemented particles.

Carbonate particles were typically recognized as medium brownish grey to dark grey well rounded particles of limestone and dolomite.

Laboratories that reported <60% silicate content particularly in the passing 4.75and retained 2.36 and passing 2.36and retained 1.18 fractions should review the examination of their samples. Weighted averages reported for silicate content by several laboratories correlate reasonably with insoluble residues of approximately 70% for this sand.

The similar ASTM standard for this test, C-295, has no precision statement.

3.4.10 LS-618 - Micro-Deval Abrasion (Coarse Aggregate) – Test No. 16

Seventy-seven laboratories reported results for this test in 2012. The test method requires reporting of control sample results to demonstrate that the testing process is in control. This year, one laboratory reported control sample results outside the established range and the lab was excluded from the analysis and identified as an outlier. In addition, four outliers were rejected using the iterative technique.

The multi-laboratory coefficient of variation of 5.5% published in the LS-618 is for 19.0 mm maximum size aggregate with abrasion losses in the range from 5% to 23%. The mean loss of 19.1% in this year's program is within the range of values for which the precision estimates were established. The average coefficient of variation of 5.4% obtained in 2012 is consistent with the value published in LS-618, and that of the values reported in the past two years (4.4% to 5.0%). The scatter plot for this test shows random variation with little laboratory bias.

3.4.11 LS-614 - Freeze-Thaw Loss – Test No. 17

The coarse aggregate samples supplied did not contain adequate amount of material retained on the 19.0 mm sieve. For this reason, participants were advised to perform the test on coarse aggregate passing the 19.0 mm sieve only and to calculate the weighted average by assigning the same freeze-thaw loss value as the next smaller fraction (i.e., 19.0 mm - 13.2 mm) for 26.5 mm to 19.0 mm that need not be tested.
Fifty-nine laboratories reported results for this test in 2012. The test method requires reporting of laboratory control sample losses to demonstrate that the testing process is in control. This information is used to alert the laboratory to testing deficiencies. Without testing of the reference material, the test is invalid (see LS-614, Section 9.1). This year, one of the laboratories reported control sample result outside the established range and was manually removed from the analysis. Additional outlier was not identified using the critical

value method or iterative technique.

The multi-laboratory coefficient of variation of 20.2% published in LS-614 is for coarse aggregate with freeze-thaw losses in the range of 4% to 18%. The coefficient of variation of 29.3% obtained in 2012 is significantly higher than the value of 20.2% published in the LS-614 and the values (16.9% to 21.0%) reported in the past three years. All of the points on the scatter plot, with the exception of seven (11.8%), are accounted in the lower left and upper right quadrant, indicating a strong laboratory bias.

It is likely that there are two main reasons for the wide spread of the data for this test: insufficient damage caused by freezing too rapidly or difference in sieving intensity. The laboratories that reported freeze-thaw losses higher than 15% and less than 5% should modify their processes to try and achieve losses closer to the mean loss of the control aggregate. Appendix 1 of LS-614 gives a procedure for determining and adjusting sieving time for quantitative analysis.

3.4.12 LS-602 - Sieve Analysis (Fine Aggregate) – Test Nos. 20-25

The test samples for this procedure were prepared by the participants from the material passing the 4.75 mm sieve of the coarse aggregate gradation. This process closely follows the normal testing procedure in which the laboratory prepares its own test samples from the field sample. The scatter diagrams for the fine aggregate sieve analysis show random variation with little laboratory bias. The standard deviations of the fine sieves in 2012 are slightly higher than that of the values reported in the 2011 study (MERO-042). The multi-laboratory variations are also found to be slightly higher than the values published in the ASTM C 136 precision statements.

As in previous interlaboratory studies, it was found that the precision of the test varies as a function of the amount of material retained on any sieve. The smaller the amount of material retained, the more efficient the sieving process and the better the precision. When there is a small amount of material retained on a sieve (one layer of particles or less), the particles have a greater chance of falling through the sieve in a given time.

The number of outliers identified varies from sieve to sieve, and ranges from twelve for the 1.18 mm sieve to a maximum of nineteen for the 150 µm sieve. Outlier laboratories with a very low percent passing the 75 µm sieve should inspect their sieves, as low percent passing may be the result of the sieve being blinded when washing the sample. An ineffective washing process will also result in a low percent passing this sieve.

3.4.13 LS-605 - Relative Density of Fine Aggregate – Test No. 27 and Absorption of Fine Aggregate – Test No. 28

Participants in the program were asked to test the samples according to MTO Test Method LS-605. This test method follows ASTM C 128, except that it requires the removal of materials finer than 75 µm by washing from the test specimen. LS-605 requires the test specimens to be prepared in duplicate and washed on the 75 µm sieve until all of the material finer than 75 µm is removed. The presence of material finer than 75 µm in the test specimens can result in lower relative densities and higher absorption values.

In the past, MTO was using the precision estimates published in the ASTM C 128 for both relative density and absorption to compare and evaluate the multi-laboratory variations obtained from the MTO proficiency sample testing program. Considering the difference in preparation of test specimen between the ASTM C 128 and LS-604, continued use of the multi-laboratory variations published in the ASTM may not be appropriate to evaluate the performance of the participating laboratories. MTO has developed precision statements recently using the data gathered through the MTO proficiency sample testing program conducted for the past twelve years. The latest revision (No. 27) of LS-604 provides precision estimates for both relative density and absorption of fine aggregates with absorption properties less than 2.0%.

One hundred and five laboratories reported results for these tests. Ten outliers for relative density (Test No. 27) and nine outliers for absorption (Test No. 28) were selected using the iterative technique. As in previous years, greater variation exists in this test compared to the relative density test on coarse aggregate. It is imperative that differential drying of the various sized particles be avoided by *constant* stirring of the sample under the air current during the drying process. As short as 30-second periods of rest can be detrimental to the outcome of the test results. Differential drying of the particles is known to cause premature collapse in the cone test used to judge the saturated surface dry state. The resulting test observations are lower relative densities and higher absorption values.

The standard deviations obtained in 2012 for both relative density (0.011 and 0.009) and absorption (0.15 and 0.16) are consistent with the values published in the LS-605 and that of the values reported in the 2009 and 2011 studies (refer Appendix C). As in the previous studies, the multi-laboratory variations obtained in 2012 are significantly lower than that of the values published in the ASTM C 128 precision statements. ASTM publishes a multi-laboratory variation of 0.023 and 0.23 for relative density and absorption, respectively for fine aggregates with absorption properties less than 1.0%. The scatter plots for both tests, especially Test No. 28, show a pronounced laboratory bias.

3.4.14 LS-621 - Amount of Asphalt Coated Particles – Test No. 30

Two hundred and sixteen laboratories reported results for this test in 2012. Eleven laboratories were identified as outliers using the iterative technique. The majority of points in the scatter diagram are accounted in the lower left and upper right quadrant of the plot indicating strong laboratory bias. LS-621 provides precision estimate for 19.0 mm maximum size coarse aggregate mixed with asphalt coated particles in the range of 25% to

45%. The average mean value of 47.4% reported by the laboratories is outside the range of values for which the precision estimate was developed. The standard deviations of 5.2 and 5.4 obtained in 2012 are significantly higher than the precision estimate of 3.8 published in the LS-621 and that of the values reported in 2011. However, the coefficient of variation obtained in 2012 (11.2%) is consistent with that of the value of 9.3% reported in 2011. Laboratories that reported values of less than 36% should critically evaluate their interpretation of the definition and re-examine their samples. There is no comparable or similar ASTM test procedure.

3.4.15 LS-623 - Moisture-Density Relationship (One-Point) – Test Nos. 31-33

Participants were asked to perform this test on the material passing the 19.0 mm sieve of the Granular A samples 1.12A and 2.12A supplied. One hundred and forty-seven laboratories reported results for this test in 2012. Fourteen outliers for the wet density (Test No. 31) and three outliers for optimum moisture (Test No. 33) determinations were rejected using the iterative technique. The standard deviations obtained in 2012 for all three tests, i.e. wet density, dry density and optimum moisture content are consistent with the values reported in 2011 and the precision estimates published in LS-623.

The majority of the points in the scatter diagrams are accounted in the lower left and upper right quadrant of the plots, indicating strong laboratory bias. Possible causes for the strong laboratory bias may be operator error and the use of an improper mould, even though the participants were requested to use only the 152.4 mm diameter mould. This test also requires significant operator skill to obtain the point within the band in the first attempt. Those laboratories with poor ratings should examine their equipment and procedure to discover the causes for this variation. There is no comparable or similar ASTM test procedure. However, ASTM D 698 covers the laboratory compaction characteristics of soils and reports precision estimates from the tests conducted on clayey soils.

3.4.16 LS-619 - Micro-Deval Abrasion (Fine Aggregate) – Test No. 34

Participants in this test were asked to prepare their own sample from the bags of bulk Granular A supplied. Seventy-seven laboratories reported results for this test in 2012. The test method requires reporting of control sample test results to demonstrate that the testing process is in control. This year, one laboratory reported control sample results outside the range established for the material. This laboratory was identified as an outlier and manually removed from the statistical analysis.
LS-619 provides precision estimates for fine aggregates with the abrasion loss in the range of 7% to 18%. The coefficient of variation of 6.2% obtained in 2012 is slightly lower than that of the precision estimate of 7.7% published in LS-619 and the values (7.1% to 8.7%) reported in the past three years.

Five outliers were selected by the use of iterative technique. The majority of the data points are located in the lower left and upper right quadrant of the scatter diagram indicating a strong laboratory bias.

3.4.18 LS-702 - Particle Size Analysis of Soil – Test Nos. 40-45

Participants in this test were instructed to submit the data sheets to demonstrate that the test was done according to LS-702. Based on the data sheets submitted, all of the laboratories performed the test in accordance with this test procedure. Seventy-six laboratories participated in the hydrometer test in 2012. All of the participants, with the exception of one laboratory, reported 100% of material passing the 2.00 mm sieve. For this reason, the data for Test No. 40 was not subjected to the statistical analysis and is reported for information purpose only.

Outliers were selected using the iterative technique. The number of outliers identified range from two for percent passing 20 um size to a maximum of five for percent passing 425 µm, 75 µm and 5 µm sizes. Successive scatter diagrams for this test show pronounced between laboratory biases. The standard deviations obtained in 2012 for all the particle sizes passing, except 20 µm, are significantly lower than that of the results reported in the past three years. The standard deviation for the 20 µm size is consistent with the results of past three years. The laboratories that are identified as outliers should examine their equipment and technician's skills to ensure that they meet the requirements of the test procedure.

3.4.19 LS-703 and 704 - Atterberg Limits of Soil – Test Nos. 46-48

Ninety-five laboratories reported results for Atterberg limit tests in 2012. Six outliers for liquid limit (Test No. 46) and nine for plastic limit test (Test No. 47) were identified using the iterative technique. The scatter plots for both liquid and plastic limit tests as well as for plasticity index (Test No. 48) show strong laboratory bias. Both liquid and plastic limit tests require significant operator skills. Liquid limit test also requires good condition and calibration of the apparatus. Close attention to the condition and calibration of the liquid limit apparatus and employing skilled technicians may reduce the laboratory biases.

The variations obtained for liquid and plastic limit tests in 2012 are consistent with those of the values reported in the past three years. Further, the standard deviations obtained for plastic limit and plasticity index are consistent with the values published in the ASTM precision statements (refer Appendix C). However, the standard deviations obtained for liquid limit test are slightly higher than that of the precision estimate published in ASTM D 4318.

3.4.20 LS-705 - Specific Gravity of Soils – Test No. 49

The participants were requested to perform this test according to LS-705. This test method requires that the test be performed on a minimum of three specimens, and the difference between the largest and smallest (range) specific gravity values of the test specimens determined is within 0.02. Further, it requires that the test be repeated if the range exceeds the specified limit. The laboratories that reported results with the range in excess of 0.02 are not capable of repeating the test within their testing environment. This year, four laboratories were identified as outliers and manually removed from the statistical analysis for exceeding the specified limit.
Seventy laboratories reported results for this test in 2012. In addition to those laboratories

that were manually removed from the analysis, six more outliers were identified using the iterative technique. Eighty-nine per cent of the data points are located in the first and third quadrants of the scatter diagram showing a strong laboratory bias. Several steps in this test procedure can influence the results, particularly the equipment and method employed for preparation of the test specimen and removal of entrapped air in the pycnometer or flask. Laboratories finding themselves in this situation should carefully examine their equipment and procedure.

The standard deviation of 0.023 obtained in 2012 is noticeably lower than the results reported in the past three years. LS-705 is similar to that of AASHTO T 100, which reports a multi-laboratory standard deviation of 0.04. As in the past three studies, the standard deviations obtained in 2012 are also found to be significantly lower than that of the precision estimate published in the AASHTO T 100.

3.5 SUPERPAVE CONSENSUS PROPERTY TESTS

3.5.1 LS-629 - Uncompacted Void Content (FA) – Test No. 95

The participants were asked to perform the test in accordance with LS-629, using the fine aggregate prepared by splitting the material passing 4.75 mm sieve of the Granular A. This test method is a modified version of AASHTO T 304. LS-629 follows Method A of AASHTO T 304, except for the preparation of the test specimen to be used in the determination of bulk specific gravity of fine aggregates. The significant difference between the methods is that LS-629 requires the test specimens be washed on the 75 µm sieve until all the material finer than 75 µm is removed. In addition, LS-629 specifies that the bulk relative density is determined using the graded sample and not the individual size fraction method described in Clause 9.4 of AASHTO T 304. In order to minimise the testing work, the participants were advised to use the bulk relative densities reported for fine aggregate determined in accordance with LS-605 under Test No. 27, to compute the uncompacted void contents of samples 3.12 and 4.12.

Seventy-one laboratories submitted results for this test in 2012. Five laboratories were identified as outliers using the iterative technique. Eighty-seven percent of the points on the scatter plot are accounted in the first and third quadrant, indicating a strong laboratory bias. The standard deviations of 0.63 and 0.66 obtained in 2012 are fairly consistent with the values obtained in the past three years. The standard deviations obtained for both samples are significantly higher than the value of 0.33% published in the ASTM precision statements for graded standard sand. The estimates of precision published in ASTM C 1252 are based on graded sand as described in ASTM C 778, which is considered rounded, and is graded from 600 µm to 150 µm. The type of material used for the development of precision statements published in ASTM C 1252 may not be typical of the sand samples that were used in this testing program. The uncompacted void contents reported by the participants were calculated using the bulk relative densities that were determined by the individual laboratories. The use of the bulk relative densities determined by the individual laboratories for the computation of uncompacted void contents further compounds the variations associated with the results reported for this test. ASTM C 1252 suggests that a difference in relative density of 0.05 will change the calculated void content by about one percent. The

laboratories that are identified as outliers should review their test procedures and the skill of the technician.

3.5.2 ASTM D 2419 - Sand Equivalent Value of Fine Aggregate - Test No. 96

Participants were asked to prepare the fine aggregate sample for this test by splitting the Granular A material passing 4.75 mm sieve. Two alternate procedures for the preparation of test specimen (air-dry or pre-wet) are allowed in both ASTM and AASHTO methods. The participants were given the option of preparing the test specimen in accordance with either method.

Sixty-seven laboratories reported results for this test in 2012. Two outliers were identified by the use of critical value method. The lower left and upper right quadrants of the scatter diagram account for 93% of the points showing strong laboratory bias. The standard deviations of 3.62 and 3.67 obtained in 2012 are significantly lower than the values reported in the past three years. These values are also, almost one-half of the multi-laboratory precision estimates of 8.0 published by ASTM for samples with sand equivalent value less than 80.

3.5.3 ASTM D 5821 - Percent of Fractured Particles – Test No. 97

The Granular A samples 1.12A and 2.12A supplied did not contain adequate amount of material retained on 19.0 mm sieve. For this reason, the participants were advised to perform the test on coarse aggregate passing the 19.0 mm sieve only.

ASTM D 5821 is very similar to MTO LS-607. Seventy-two laboratories submitted results for this test in 2012. Two outliers were detected using the iterative technique. The scatter diagram shows a pronounced between-laboratory bias. The average means determined by the ASTM method (78.7%) and MTO version (77.2%) on the same aggregate samples differs only by 1.5%. The difference in the mean values of both methods is significantly lower than the precision estimate of 5.2 published by ASTM and the value of 4.7 published in LS-608. Further, the standard deviations of 5.4 and 6.4 obtained by ASTM are also almost similar to that of the values (5.6 and 5.9) determined by LS-608. ASTM has not conducted interlaboratory studies to determine a precision estimate and currently publishes statistical data provided by MTO. The variation obtained in 2012 is consistent with that of the values (4.9 and 5.4) obtained in 2011 and the value of 5.2 published in ASTM precision statements.

3.5.4 ASTM D 4791 - Percent Flat and Elongated Particles – Test No. 99

The coarse aggregate samples supplied did not contain adequate amount of material retained on the 19.0 mm sieve. For this reason, participants were advised to perform the test on coarse aggregate passing the 19.0 mm sieve only, using a ratio of 5:1 and to calculate the weighted average by assigning the same percent flat and elongated particles value as the next smaller fraction (i.e., 19.0 mm - 13.2 mm) for 26.5 mm to 19.0 mm that need not be tested. Seventy-two laboratories reported results for this test in 2012. Six outliers were detected using the iterative technique. The standard deviations of 0.32 and 0.46 obtained in 2012 are

significantly higher than the values reported in 2011. However, the average coefficient of variation of 64.5% obtained in 2012 is significantly lower than the value of 81.8% obtained in 2011 and consistent with the values of 62.5% and 52.4% obtained in 2009 and 2010, respectively. The majority of points on the scatter plot are located in the first and third quarter indicating significant laboratory bias.

ASTM D 4791 provides precision estimates for three individual fractions ranging from 19.0 mm to 13.2 mm, 13.2 mm to 9.5 mm, and 9.5 mm to 4.75 mm. However, the results reported in this study are based on the weighted average calculated from five fractions ranging from 26.5 mm to 4.75.mm. For this reason, a direct comparison of the multi-laboratory variations obtained in this study with that of the precision estimates published by ASTM is not possible.

4. Laboratory Rating System

The laboratory rating system assigns separate overall ratings for each category of laboratories, i.e., low complexity (Production) aggregate laboratories, high complexity (Full Service) Aggregate laboratories, Soil laboratories, and Superpave laboratories. Laboratories must participate in all of the tests that are listed under each category (i.e., Production, Full Service, Soil and Superpave) to assign an overall laboratory rating. Production (CCIL Type C) laboratories are required to carry out wash pass 75 μm, sieve analysis, percent crushed particles, percent asphalt coated particles, and percent flat and elongated particles tests. In addition to these tests, Full Service laboratories (CCIL Type D) must carry out micro-Deval (coarse and fine), freeze-thaw, and/or magnesium sulphate soundness, relative density and absorption (coarse and fine) tests. Soil laboratories are required to carry out particle size analysis, Atterberg limits, and specific gravity of soil tests. Superpave aggregate laboratories are required to perform all four consensus property tests (i.e. uncompacted void content, sand equivalent value, percent fractured particles, and flat and elongated particles).

The rating system gives a maximum rating of 10 for each test, (e.g. 5 for wash pass 75 μm on sample 1.12, plus -5 for wash pass 75 μm on sample 2.12, equals 10 (the negative sign indicating a test result less than the mean is ignored)). See Section 2.1 for explanation of test method ratings. Some tests that are normally reported together are averaged and given a maximum of 10. The relative density and absorption (coarse and fine), one-point Proctor values (maximum wet and dry density, and optimum moisture content), particle size analysis of soils, and Atterberg limits are treated in this manner. Because of the large number of individual test ratings in the sieve analysis results, the ratings are modified so as not to unduly bias the overall balance between various tests. The ratings for each sieve size are added and then divided by eleven coarse and fine sieves for which results were reported, and multiplied by 3 to give a laboratory rating with a maximum of 30 for this test. Individual laboratory ratings are calculated by adding the ratings of each test in the appropriate lab category (i.e. Production, Full Service, Soil, or Superpave) and converting the sum to a percentage of the maximum available rating for the category. The spread of laboratory ratings for Production, Full Service, Soil, and Superpave laboratories are given in the form of histograms in Figures 2 to 5. The rating system for "Full Service Laboratory" (Type D) shows that 54% of the participating laboratories in 2012 obtained a rating higher than 90 and, in the case of consensus property tests (Superpave), 58% of the participants obtained an overall laboratory rating higher than 90. The laboratory rating system data is reported in the Appendices E1, E2, E3, and E4.

Laboratory ratings for each category are given to participants in the covering letter accompanying the individual laboratory results. A poor or good rating for a laboratory in one year is an indication of how that laboratory performed in the proficiency study, and may not be a reflection of how the laboratory performs year round. A consistently poor rating over two or more years may be cause for serious concern.

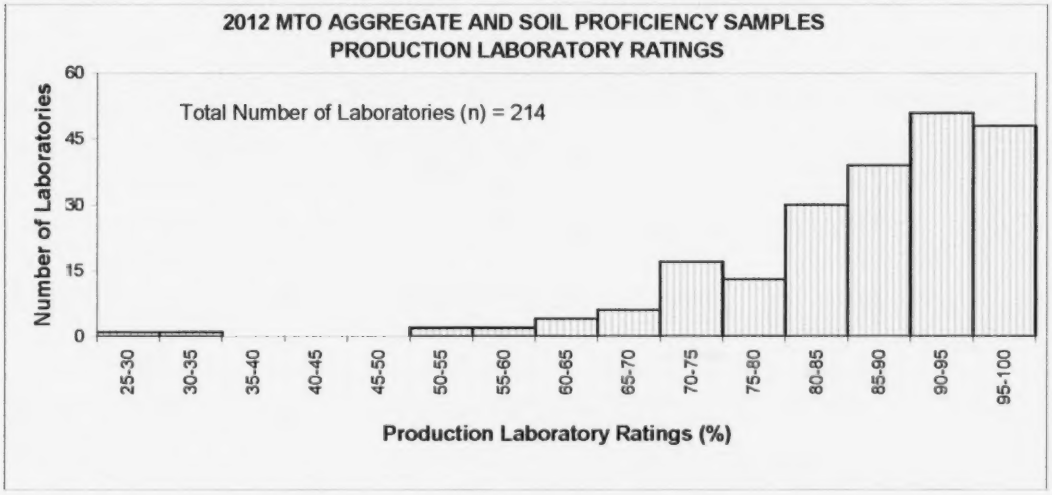


Figure 2. Production Laboratory Ratings

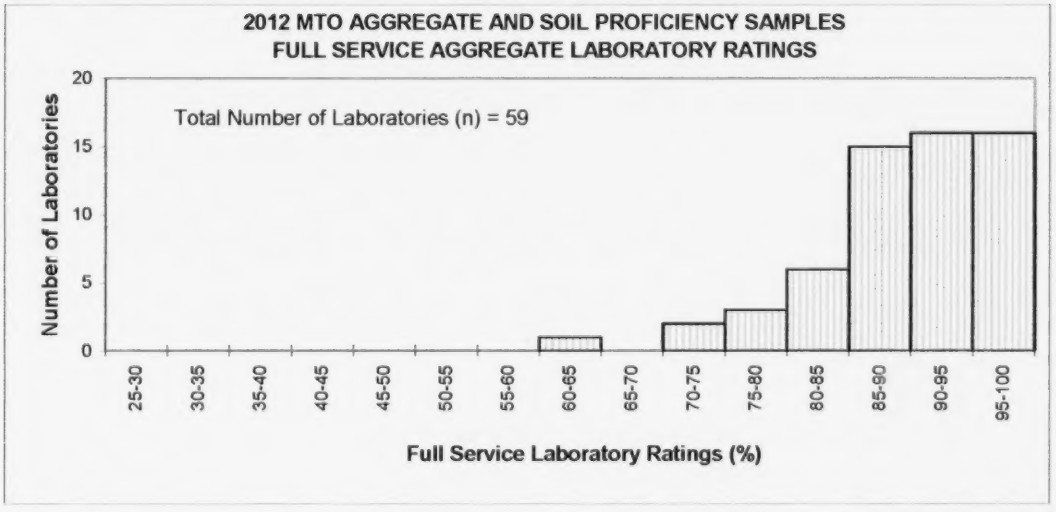


Figure 3. Full Service Laboratory Ratings

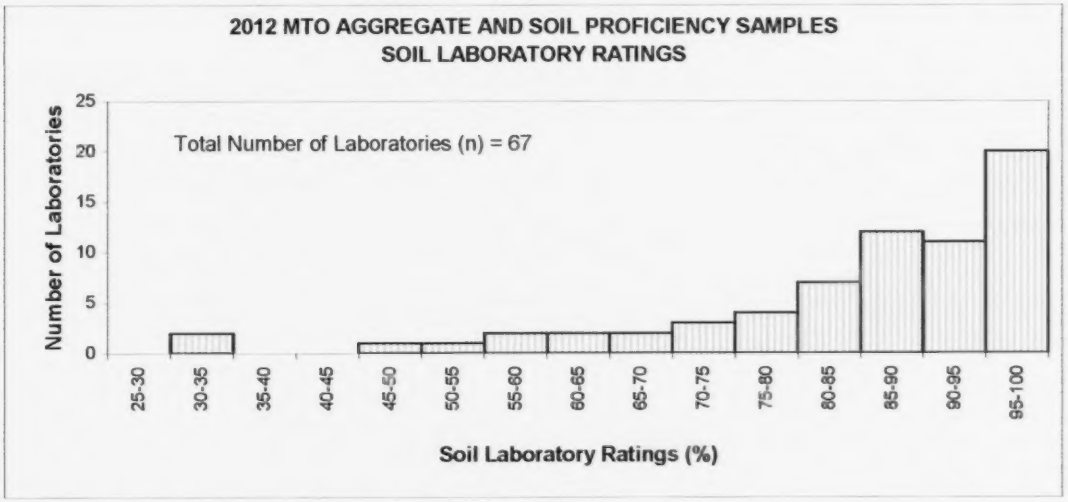


Figure 4. Soil Laboratory Ratings

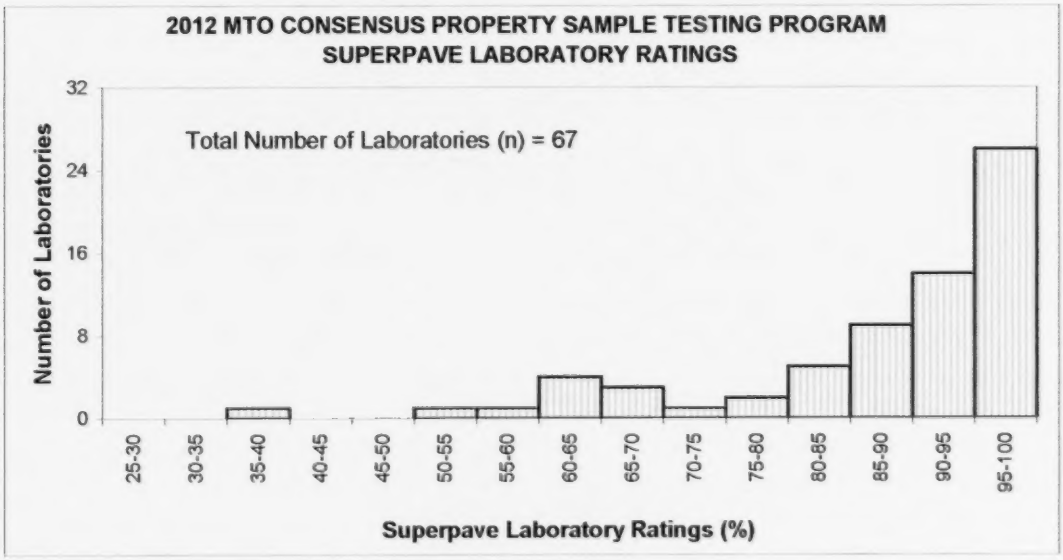


Figure 5. Superpave Laboratory Ratings

5. Conclusions

The method of proficiency sample preparation employed by MTO resulted in almost identical mean gradation values for samples 1.12 and 2.12. The differences in mean, as well as in the standard deviations between pairs of samples for both coarse and fine sieves are almost negligible. Based on the results, it may be concluded that the sample preparation method employed is very effective and capable of producing a uniform and nearly identical material at reasonable cost.

The majority of the aggregate and soil test results of the 2012 Aggregate and Soil Proficiency Sample Testing Program compare favourably with the results of previous studies. In some cases, the variations show noticeable improvement over previous years' results and the precision estimates of those tests where MTO or ASTM precision statements are available. The scatter diagrams for the majority of the aggregate tests show either random variation or a combination of random variation and laboratory bias for some laboratories.

Two hundred and fourteen of the laboratories that participated in the aggregate tests are CCIL Type C (Production) certified, and fifty-nine of those are also CCIL Type D (Full Service) certified. CCIL inspects the certified laboratories for quality control procedures, ability of technicians, and condition and calibration of the equipment at about eighteen month intervals. The performance of laboratories in most of the aggregate tests (Type C and Type D) is consistent with the results in the past and a large number of these tests show improvement in multi-laboratory variation over the established precision estimates. The improvements noted may be due to the on-site laboratory inspection by CCIL at regular intervals, proficiency sample testing, and due to an increased awareness of the importance of proper testing and quality control procedures implemented by CCIL.

Sixty-seven laboratories participated in all three soil tests. The variations found in 2012 for the soil tests are noticeably lower than that of the values reported in the last three years' studies, but the scatter diagrams still show strong laboratory biases. The results of soil tests are significantly influenced by operator skills, testing environment, and the condition and calibration of the equipment. Thirty-seven of the sixty-seven laboratories that participated in the soil tests are on the MTO Vendors List. Most of the laboratories that are on the MTO Vendors List were inspected more than six to eight years ago by MTO staff by request and only a few re-inspections[8] have been done to date.

Sixty-seven laboratories participated in all four Superpave consensus property tests. The results of 2012 compare favourably with the results of past three years. However, the multi-laboratory precisions obtained in 2012, except uncompacted void content, show improvement over the ASTM precision estimates. As in the past, the scatter diagrams for all four tests show strong laboratory biases. It is expected that the quality control program implemented by CCIL will bring about improvements in multi-laboratory variation.

8 To arrange an inspection of your Soil Laboratory, please contact Mark Vasavithasan, Soils and Aggregates Section, Ministry of Transportation, phone (416) 235-4901, fax (416) 235-4101, Mark.Vasavithasan@ontario.ca.

6. Recommendations

Although, there are improvements in the multi-laboratory variations over the precision estimates established by ASTM and MTO, strong laboratory biases still remain in a number of aggregate tests and all of the soil test procedures. The laboratories that were identified as outliers should examine their quality control practices, the condition and calibration of equipment, testing procedures, and skills of the technicians. Laboratories must investigate the causes and prepare corrective action reports as required by the quality system whenever a rating of 2 or less is obtained for each sample in a test.

The results of the 2012 MTO Aggregate and Soil Proficiency Sample Testing Program suggest that most laboratories have performed satisfactorily. Laboratories that obtained relatively low ratings must focus on quality control practices, operator training, standardization and calibration of equipment, and improvements to laboratory environment in order to improve their performance.

For all of the tests that were included in this study, the equipment to be used is regulated by the test method itself. A good state of equipment maintenance, repair, and correct calibration is required in order to achieve improvements. It is hoped that the mandatory Quality System implemented by CCIL will encourage laboratories to conduct a review of their internal quality control practices to ensure that they have the correct equipment and properly trained technicians. Laboratories will find that a well-documented and regular program of internal inspection, calibration, and testing of control or reference samples is beneficial to maintaining a high level of confidence in their results.

7. Acknowledgments

The authors would like to acknowledge Bob Gorman of the Soils and Aggregates Section for the selection of aggregate materials for the 2012 proficiency sample testing program. We would also like to thank the many laboratory staff, students and engineers-in-training of the Materials Engineering and Research Office for their dedicated assistance in preparing more than 2200 individual samples, from almost 50 tonnes of aggregate and soil material, for distribution to the program participants.

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Appendix A: Glossary of Terms

Acceptable difference between two results (difference two-sigma limit (d2s)) as an index of precision is the maximum acceptable difference between two results obtained on test portions of the same material tested by two different laboratories. The index, d2s, is the difference between two individual test results that would be equalled or exceeded in only one case in twenty in the normal and correct operation of the method. The index is calculated by multiplying the multi-laboratory standard deviation (1s) by the factor $2\sqrt{2}$ (2.83).

Accuracy refers to the degree of mutual agreement between a set of measurements with an accepted reference or 'true value'. This 'true' or reference value can be an assigned value arrived at by actual experiments.

Bias of a measurement process is a consistent and systematic difference between a set of test results derived from using the process and an accepted reference value of the property being measured. For the majority of aggregate and soil tests, there is no acceptable reference material, so bias is impossible to compute.

Coefficient of Variation expresses the standard deviation as a percentage of the mean, where: $C.V. = \frac{\text{std dev}}{\text{mean}} \times 100$

Critical Value is that value of the sample criterion which would be exceeded by chance with some specified probability (significance level) on the assumption that all the observations did indeed constitute a random sample from a common system of causes.

MAIDB refers to Mineral Aggregate Inventory Data Bank of the Ministry of Transportation.

Median is synonymous with the middle and the **sample median** is the middle value of a list of test results when the observations are ordered from smallest to largest in magnitude. After rearranging the observations in increasing order (from most negative to most positive), the **sample median** is the *single middle value* in the ordered list, if n is odd, or the *average of the two middle values* in the ordered list, if n is even, where n equals the number of observations.

Multi-laboratory precision is a quantitative estimate of the variability of a large group of individual test results when each test has been made in a different laboratory and every effort has been made to make test portions of the material as nearly identical as possible. Under normal circumstances, the estimates of the one-sigma limit (1s) for multi-laboratory precision are usually larger than those for single-operator precision because different operators and different equipment are being used in different laboratories.

Outlier is a measurement that, for a specific degree of confidence, is not part of the population. In this study, an outlier is generally three or more standard deviations from the mean, giving a confidence level of ninety-nine percent. If a laboratory test result is classified

as an outlier, it means that something went wrong either with the sample or in the laboratory.

Precision refers to the degree of mutual agreement between individual measurements on the same material. In other words, precision is a measure of how well the individual test results of a series agree with each other.

Sample mean or average is the sum of all observations divided by the total number of observations.

Single operator precision (one-sigma limit (1s)) indicates the variability, as measured by the deviations above and below the average, of a large group of individual test results when the tests have been made on the same material by a single operator using the same apparatus in the same laboratory over a relatively short time.

Standard deviation is the most usual measure of the dispersion of observed values or results expressed as the positive square root of the variance.

Variance is a measure of the squared dispersion of observed values or measurements expressed as a function of the sum of the squared deviations from the population mean or sample average.

Appendix B1: List of Participants

2012 Participants List Ministry of Transportation Aggregate and Soil Proficiency Sample Testing Program For further information on this program, contact: Mark Vasavithasan (416) 235-4901, or Stephen Senior (416) 235-3734	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS- 623 One Point Proctor Density	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
A. L. Blair Construction Limited Moose Creek, ON Mr. Bryan Blanshard Tel: 613 538-2271	✔	✔				✔	✔							✔				
AGS Associates Inc. Scarborough, ON Mr. Amjed Siddiqui Tel: 416 299-3655	✔	✔		✔	✔	✔	✔				✔	✔		✔	✔		✔	✔
AME - Materials Engineering Caledon, ON Mr. Scott Crowley Tel: 905 840-5914	✔	✔		✔	✔	✔	✔	✔		✔	✔	✔	✔	✔	✔	✔	✔	✔
AME - Materials Engineering Stouffville, ON Mr. Jordan Gadjanov Tel: 905 640-7772	✔	✔		✔	✔	✔	✔	✔		✔	✔	✔		✔	✔	✔	✔	✔
AME - Materials Engineering Ottawa, ON Mr. Harrison Smith Tel: 613 726-3039	✔	✔		✔	✔	✔	✔			✔	✔	✔		✔	✔	✔	✔	✔
AME - Materials Engineering (24-165) Caledon, ON Mr. Scott Crowley Tel: 905 840-5914	✔	✔				✔	✔							✔	✔			
AME - Materials Engineering (24-270) Caledon, ON Mr. Scott Crowley Tel: 905 840-5914	✔	✔				✔	✔							✔	✔			
AME - Materials Engineering (24-271) Caledon, ON Mr. Scott Crowley Tel: 905 840-5914	✔	✔				✔	✔							✔	✔			
AME - Materials Engineering (24-297) Caledon, ON Mr. Scott Crowley Tel: 905 840-5914	✔	✔				✔	✔							✔	✔			
AME - Materials Engineering (24-298) Caledon, ON Mr. Scott Crowley Tel: 905 840-5914	✔	✔				✔	✔							✔	✔			
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2012 Participants List

Ministry of Transportation

Aggregate and Soil

Proficiency Sample

Testing Program

For further information on this program, contact:

Mark Vasavithasan (416) 235-4901, or
Stephen Senior (416) 235-3734

	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS- 623 One Point Proctor Density	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
AMEC Earth & Environmental Ltd. Hamilton, ON Mr. John Balinski Tel: 905 312-0700	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
AMEC Earth & Environmental Ltd. Cambridge, ON Mr. Louis Maier Tel: 519 650-7115	✓	✓		✓		✓	✓				✓	✓		✓	✓	✓	✓	✓
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BOT Construction Oakville, ON Mr. Vicks Sellathurai Tel: 905 827-3250	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
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Dufferin Construction Limited - Cayuga Cayuga, ON Mr. Waqas Syed Tel: 905 827-5750	✓	✓		✓		✓	✓							✓	✓			
Dufferin Construction Limited - Mobile 1 Oakville, ON Mr. Waqas Syed Tel: 905 827-5750	✓	✓		✓		✓	✓							✓	✓			
Dufferin Construction Limited - Mobile 2 Oakville, ON Mr. Waqas Syed Tel: 905 827-5750	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Dufferin Construction Limited - Mobile 3 Oakville, ON Mr. Waqas Syed Tel: 905 827-5750	✓	✓		✓		✓	✓							✓	✓			
Dufferin Construction Ltd. (QC) Oakville, ON Mr. Waqas Syed Tel: 905 827-5750	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
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Harold Sutherland Construction Ltd. Kemble, ON Mr. Roland Leigh Tel: 519 376-3506	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓			
Holcim Canada Inc. Etobicoke, ON Mr. G. Julio-Betancourt Tel: 416 744-2206	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓			✓	
Houle Chevrier Engineering Limited Carp, ON Mr. Andrew Chevrier Tel: 613 836-1422	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓
Huron Construction Co. Ltd. Chatham, ON Mr. David Smith Tel: 519 354-0170	✓	✓				✓	✓							✓	✓			
Inspec-sol Inc. Kingston, ON Mr. Mark Patterson Tel: 613 389-9812	✓	✓				✓	✓							✓	✓			
Inspec-Sol Inc. Mississauga, ON Mr. Raj Kadia Tel: 905 712-4771	✓	✓				✓	✓							✓	✓	✓	✓	✓
Inspec-sol Inc. Ottawa, ON Mr. Daniel Boateng Tel: 613 727-0895	✓	✓				✓	✓							✓	✓			
Inspec-Sol Inc. Waterloo, ON Mr. Bruce Polan Tel: 519 725-9328	✓	✓				✓	✓							✓	✓	✓	✓	✓
Interpaving Asphalt & Aggregate Supply Ltd. Sudbury, ON Ms. Ashley Edwards Tel: 705 694-6210	✓	✓		✓		✓	✓	✓			✓	✓		✓	✓		✓	
Intratech Engineering Laboratories Inc. Scarborough, ON Mr. Frank Miles Tel: 416 754-2077	✓	✓		✓	✓	✓	✓			✓				✓	✓	✓	✓	✓
J & P Leveque Bros. Ltd. - Mobile 616 Bancroft, ON Mr. Shawn Fransky Tel: 613 332-5533	✓	✓				✓	✓				✓	✓		✓	✓		✓	
J & P Leveque Bros. Ltd. – Mobile 617 Bancroft, ON Mr. Shawn Fransky Tel: 613 332-5533	✓	✓				✓	✓				✓	✓		✓	✓		✓	
John D. Paterson & Associates Ottawa, ON Mr. Stephen Walker Tel: 613 226-7381	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓

2012 Participants List

Ministry of Transportation

Aggregate and Soil

Proficiency Sample

Testing Program

For further information on this program, contact:

Mark Vasavithasan (416) 235-4901, or
Stephen Senior (416) 235-3734

	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS- 623 One Point Proctor Density	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
John D. Paterson & Associates North Bay, ON Mr. Shawn Nelson Tel: 707 472-5331	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
K. J. Beamish Construction - Mobile 1 King City, ON Mr. Chad Henderson Tel: 905 833-4666	✓	✓				✓								✓	✓			
K. J. Beamish Construction - Mobile 2 King City, ON Mr. Chad Henderson Tel: 905 833-4666	✓	✓				✓	✓							✓	✓			
K.J. Beamish Construction King City, ON Mr. Chad Henderson Tel: 905 833-4666	✓	✓		✓		✓	✓	✓		✓	✓	✓		✓	✓		✓	
Lafarge Canada Orono, ON Mr. Frances Clements Tel: 905 983-9260	✓	✓				✓	✓							✓				
Lafarge Canada – Mobile 434 Cold Water, ON Ms. Sarah Brown Tel: 705 326-5850	✓	✓				✓	✓							✓				
Lafarge Canada - Orillia Lab Cold Water, ON Ms. Sarah Brown Tel: 705 326-5850	✓	✓				✓	✓							✓				
Lafarge Canada Inc. Brechin, ON Ms. Christine Crumbie Tel: 705 484-5225	✓	✓				✓	✓				✓	✓		✓				
Lafarge Canada Inc. Dundas, ON Mr. Chris Thomas Tel: 905 977-7363	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓	✓	✓		✓	
Lafarge Canada Inc. Cambridge, ON Mr. Michael Koch Tel: 519 319-9128	✓	✓				✓	✓							✓				
Lafarge Canada Inc. Fonthill, ON Mr. Michael Koch Tel: 905 522-7735	✓	✓				✓	✓							✓				
Lafarge Canada Inc. Hamilton, ON Mr. Michael Koch Tel: 905 979-3107	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓	✓			✓	
Lafarge Canada Inc. London, ON Mr. Michael Koch Tel: 519 319-9128	✓	✓				✓	✓							✓				
Lafarge Canada Inc. Paris, ON Mr. Michael Koch Tel: 905 522-7735	✓	✓				✓	✓							✓				
Lafarge Canada Inc. Meldrum Bay, ON Mr. Jeff Middleton Tel: 705 283-3011	✓	✓				✓	✓							✓				
Lafarge Canada Inc. Ottawa, ON Mr. Fred Douglas Tel: 613 830-3060	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓		✓	
Lafarge Canada Inc. Stouffville, ON Ms. Christine Crumbie Tel: 905 640-5883	✓	✓				✓	✓							✓				

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For further information on this program, contact:

Mark Vasavithasan (416) 235-4901, or
Stephen Senior (416) 235-3734

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Lafarge Canada Inc. Caledon, ON Mr. Chris Thomas Tel: 519 927-1113	✓	✓				✓	✓							✓				
Lafarge Canada Inc. – Pt. Anne Quarry Belleville, ON Mr. Jason Malcolm Tel: 613 813-4857	✓	✓				✓	✓							✓				
Lafarge Construction Materials Ltd. Brockville, ON Mr. Paul Arkeveld Tel: 613 349-7422	✓	✓				✓	✓			✓	✓	✓		✓				
Lafarge Construction Materials Ltd. Glenburnie, ON Mr. Paul Arkeveld Tel: 613 349-7422	✓	✓				✓	✓							✓				
Lavis Contracting Co. Limited Clinton, ON Mr. Allan Gardner Tel: 519 482-3694	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓		✓	✓		✓	
Law Engineering (London) Inc. London, ON Mr. Joe Law Tel: 519 680-9991	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓
LVM Inc. Kitchener, ON Mr. Jason Taylor Tel: 519 741-1313	✓	✓		✓		✓	✓				✓	✓		✓	✓	✓	✓	✓
LVM Inc. Branford, ON Mr. David Baillie Tel: 519 720-0078	✓	✓				✓	✓							✓	✓	✓	✓	
LVM Inc. Stratford, ON Ms. Amy Helle Tel: 519 273-0101	✓	✓				✓	✓							✓	✓	✓	✓	
LVM Inc. Toronto, ON Mr. Dawit Amar Tel: 416 213-1060	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
LVM/Merlex North Bay, ON Mr. J. P. Duhaime Tel: 705 476-2550	✓	✓				✓	✓							✓	✓	✓	✓	✓
McAsphalt Engineering Services Toronto, ON Mr. Michael Esenwa Tel: 416 281-8181	✓	✓		✓		✓	✓							✓	✓			
Mill-Am Corporation - Mobile 890901 Oldcastle, ON Mr. Cesare Di Cesare Tel: 519 945-7441	✓	✓		✓		✓	✓							✓	✓			
Miller Northwest Limited Dryden, ON Ms. Melodie Asselin Tel: 807 223-2844	✓	✓				✓	✓							✓				
Miller Northwest Limited - Mobile 942012 Dryden, ON Ms. Melodie Asselin Tel: 807 223-2844	✓	✓		✓		✓	✓							✓	✓			
Miller Paving Limited Markham, ON Mr. Peng Du Tel: 905 475-6660	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓		✓	
Miller Paving Limited Port Colborne, ON Mr. Narayan Hanasoge Tel: 905 834-9227	✓	✓		✓		✓	✓				✓	✓		✓	✓			

2012 Participants List

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Mark Vasavithasan (416) 235-4901, or
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Miller Paving Limited Whitby, ON Ms. Carla Hariprashad Tel: 905 655-3889	✓	✓				✓	✓							✓				
Miller Paving Limited - Carden Quarry Brechin, ON Mr. Narayan Hanasoge Tel: 705 484-1101	✓	✓				✓	✓							✓				
Miller Paving Limited - Mobile Brechin, ON Mr. Narayan Hanasoge Tel: 705 484-1101	✓	✓				✓	✓							✓				
Miller Paving Limited - Mobile 8661 North Bay, ON Mr. Herb Villneff Tel: 705 472-3312	✓	✓				✓	✓							✓	✓			
Miller Paving Limited - Patterson Quarry Utterson, ON Mr. Narayan Hanasoge Tel: 705 385-0249	✓	✓				✓	✓							✓				
Miller Paving Ltd. – Mobile 60853 North Bay, ON Mr. Herb Villneff Tel: 705 472-3312	✓	✓		✓		✓	✓							✓	✓			
Miller Paving Ltd. – Mobile 8660 North Bay, ON Mr. Herb Villneff Tel: 705 472-3312	✓	✓				✓	✓							✓	✓			
Miller Paving Northern - Mobile 1084 North Bay, ON Mr. Herb Villneff Tel: 705 472-3312	✓	✓		✓		✓	✓							✓	✓			
Miller Paving Northern - Mobile 1254 North Bay, ON Mr. Herb Villneff Tel: 705 472-3312	✓	✓		✓		✓	✓				✓	✓		✓	✓			
Miller Paving Northern - Mobile 50612 North Bay, ON Mr. Herb Villneff Tel: 705 472-3312	✓	✓		✓		✓	✓							✓	✓			
Miller Paving Northern - Mobile 60889 North Bay, ON Mr. Herb Villneff Tel: 705 472-3312	✓	✓		✓		✓	✓							✓	✓			
Ministry of Transportation Downsview, ON Mr. Stephen Senior Tel: 416 235-3734	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ministry of Transportation – PN2 Downsview, ON Mr. Stephen Senior Tel: 416 235-3734								✓										
MNA Engineering Limited Scarborough, ON Mr. Peter Balendran Tel: 416 757-8882	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Nasiruddin Engineering Limited Mississauga, ON Mr. Shakeel Nasiruddin Tel: 905 565-9595	✓	✓		✓		✓	✓							✓	✓			
National Testing Laboratories Limited Winnipeg, MB Mr. Jason Thompson Tel: 204 488-6999	✓	✓	✓	✓							✓	✓				✓	✓	
Nelson Aggregate Co. Beamsville, ON Mr. Shawn Warkholdt Tel: 905 563-8226	✓	✓				✓	✓							✓				

2012 Participants List

Ministry of Transportation

Aggregate and Soil

Proficiency Sample

Testing Program

For further information on this program, contact:

Mark Vasavithasan (416) 235-4901, or
Stephen Senior (416) 235-3734

	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS- 623 One Point Proctor Density	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
Nelson Aggregate Co. Burlington, ON Mr. Michael Rook Tel: 905 335-5250	✓	✓				✓	✓							✓				
Nelson Aggregate Co. Orillia, ON Mr. Chris Roote Tel: 705 325-2264	✓	✓				✓	✓							✓				
Peto MacCallum Limited Barrie, ON Mr. Andrew Jones Tel: 705 734-3900	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Peto MacCallum Limited Hamilton, ON Mr. Amjad Khan Tel: 905 561-2231	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Peto MacCallum Limited Kitchener, ON Mr. Gerry Mitchell Tel: 519 893-7500	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
Peto MacCallum Limited Toronto, ON Mr. Alnoor Nathoo Tel: 416 785-5110	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Pioneer Construction Inc. Sault Ste. Marie, ON Mrs. Shelley Geiling Tel: 705 541-2280	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓			
Pioneer Construction Inc. Copper Cliff, ON Mr. David Pilkey Tel: 705 693-1363	✓	✓		✓		✓	✓	✓		✓	✓	✓		✓	✓			
Pioneer Construction Inc. Thunder Bay, ON Mr. Tony Fazio Tel: 807 345-2338	✓	✓		✓		✓	✓							✓	✓			
Port Colborne Quarries Inc. Port Colborne, ON Mr. Tim Cassibo Tel: 905 834-3647	✓	✓				✓	✓							✓				
Preston Sand & Gravel Kitchener, ON Mr. Matthew Bell Tel: 519 242-0902	✓	✓				✓	✓							✓				
R. W. Tomlinson Limited Ottawa, ON Mr. Bert Hendriks Tel: 613 822-0543	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓		✓	✓
R.S Wilson Materials Testing & Inspection Sault Ste. Marie, ON Mr. Robert Wilson Tel: 705 759-2881	✓	✓		✓		✓	✓							✓	✓			
Regional Municipality of Durham Whitby, ON Mr. Joeman Ng Tel: 905 655-3344	✓	✓				✓	✓							✓	✓			
Sarafinchin Associates Limited Rexdale, ON Mr. Scott [illegible]ffrey Tel: 416 674-1770	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Shaba T[illegible]g Services Limited Kirkland L[illegible]e, ON Mr. Lad Shaba Tel: 705 567-4187	✓	✓				✓	✓							✓	✓			
Shaheen Peaker Thompson Limited Oshawa ON Mr. Dave Thompson Tel: 905 436-9028	✓	✓		✓	✓	✓	✓			✓				✓	✓	✓	✓	✓

2012 Participants List

Ministry of Transportation

Aggregate and Soil

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Mark Vasavithasan (416) 235-4901, or
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Smelter Bay Aggregates Inc. Thessalon, ON Mr. Charles Hernden Tel: 705 842-2597	✓	✓				✓	✓							✓				
Soil Engineers Limited Scarborough, ON Mr. S. Sanjeevan Tel: 416 754-8515	✓	✓				✓	✓							✓	✓	✓	✓	✓
St Lawrence Testing & Inspection Co. Ltd. Cornwall, ON Mr. Gib McIntee Tel: 613 938-2521	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
St. Marys Leaside Lab Toronto, ON Mr. Stephen Parkes Tel: 416 423-2439	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓	✓				
Stantec Consulting Limited Ottawa, ON Mr. Jeff Weng Tel: 613 738-0708	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓
Stantec Consulting Limited Kitchener, ON Mr. Kenton Power Tel: 519 579-4410	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Stantec Consulting Limited Markham, ON Ms. Brani Vujanovic Tel: 905 479-9345	✓	✓		✓		✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓
Steed and Evans Limited Heidelberg, ON Mr. Richard Marco Tel: 519 699-4646	✓	✓		✓		✓	✓							✓				
Taranis Contracting Group Thunder Bay, ON Mr. Dawn Molcan Tel: 807 475-5433	✓	✓				✓	✓							✓				
TBT Engineering Limited Thunder Bay, ON Mr. Tim Fummerton Tel: 807 624-5162	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
Teranorth Construction & Engineering Ltd. Sudbury, ON Mr. James Bot Tel: 705 523-1540	✓	✓				✓	✓							✓	✓			
Terraprobe Inc. Brampton, ON Mr. Chris Elvidge Tel: 905 796-2650	✓	✓		✓		✓	✓	✓			✓	✓		✓	✓	✓	✓	✓
Terraprobe Inc. Barrie, ON Mr. Brian Jackson Tel: 705 739-8355	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Terraprobe Inc. Stoney Creek, ON Mr. Gerry Muckle Tel: 905 643-7560	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Terraprobe Inc. Sudbury, ON Mr. Dennis Paquette Tel: 705 670-0460	✓	✓				✓	✓							✓	✓	✓	✓	✓
Terraspec Engineering Inc. Peterborough, ON Mr. Shane Galloway Tel: 705 743-7880	✓	✓				✓	✓							✓	✓	✓	✓	✓
The Karson Group Carp, ON Mr. Cam MacDonald Tel: 613 831-0717	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓	✓				

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The Miller Group Materials Research Lab Gormley, ON Mr. Narayan Hanasoge Tel: 905 726-9518	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	
The Murray Group Moorefield, ON Mr. Brad Mitchell Tel: 519 323-4411	✓	✓				✓	✓							✓				
Thomas Cavanagh Construction – Mobile Ashton, ON Mr. Phil White Tel: 613 257-2918	✓	✓				✓	✓							✓				
Thomas Cavanagh Construction Ltd. Ashton, ON Mr. Phil White Tel: 613 257-2918	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓		✓	✓
Thurber Engineering Limited Oakville, ON Mr. Weiss Mehdawi Tel: 905 829-8666	✓	✓				✓	✓							✓	✓	✓	✓	✓
Tri City Materials Petersburg, ON Mr. Ron Shantz Tel: 519 577-1000	✓	✓				✓	✓							✓				
True Grit Consulting Ltd. Thunder Bay, ON Mr. Adam Rose Tel: 807 626-5640	✓	✓				✓	✓							✓		✓	✓	✓
Tulloch Engineering Inc. Sault Ste. Marie, ON Mr. Daren Stadnisky Tel: 705 945-5090	✓	✓		✓		✓	✓				✓	✓		✓	✓	✓	✓	
Vicdom Sand and Gravel Limited Uxbridge, ON Mr. Bruno Giordano Tel: 905 649-2193	✓	✓				✓	✓							✓				
Walker Aggregates Inc. Thorold, ON Mr. Tom Risi Tel: 905 227-4142	✓	✓		✓	✓	✓	✓				✓	✓		✓				
Walker Aggregates Inc. Duntroon, ON Mr. Tom Risi Tel: 905 445-2300	✓	✓				✓	✓							✓				

Appendix B2: List of Participants

2012 Participants List Ministry of Transportation Superpave Aggregate Consensus Property Testing Program For further information on this program, contact: Mark Vasavithasan (416) 235-4901 or Stephen Senior (416) 235-3734	ASTM D 1252/AASHTO T 304 - Uncompacted Void Content of Fine Aggregate	ASTM D 4219/AASHTO T 176 – Sand Equivalent Value of Fine	ASTM D 5821 – Percent of Fractured Particles in Coarse Aggregate	ASTM D 4791 – Percent Flat Particles, Elongated Particles or Flat & Elongated Particles in Coarse Aggregate
AME -Materials Engineering Stouffville, ON Mr. Jordan Gadjanov Tel: 905 640-7772	✔	✔	✔	✔
AME -Materials Engineering Caledon, ON Mr. Scott Crowley Tel: 905 840-5914	✔	✔	✔	✔
AME -Materials Engineering Ottawa, ON Mr. Harrison Smith Tel: 613 726-3039	✔	✔	✔	✔
AMEC Earth & Environmental Limited Cambridge, ON Mr. Louis Maier Tel: 519 650-7115	✔	✔	✔	✔
AMEC Earth & Environmental Limited Hamilton, ON Mr. John Balinski Tel: 905 312-0700	✔	✔	✔	✔
AMEC Earth & Environmental Limited Scarborough, ON Mr. Mohammadsarif. Sufi Tel: 416 751-6565	✔	✔	✔	✔
AMEC Earth & Environmental Limited Tecumseh, ON Mr. Justin Palmer Tel: 519 735-2499	✔	✔	✔	✔
C. Villeneuve Construction – Mobile 1 Hearst, ON Mr. Charles Harris Tel: 705 372-1838	✔	✔	✔	✔
COCO Paving Inc. Windsor, ON Mr. Ishaq Syed Tel: 519 948-7133	✔	✔	✔	✔
COCO Paving Inc. Ottawa, ON Mr. Brad Gooderham Tel: 613 907-7283	✔	✔	✔	✔
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Ministry of Transportation

Superpave Aggregate Consensus Property Testing Program

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Appendix C: Multi-Laboratory Precision

Test 1	2009		2010		2011		2012		MTO LS-601
WP 75 μm	1.09	2.09	1.10	2.10	1.11	2.11	1.12	2.12	
Mean	1.97	1.90	0.56	0.55	0.97	1.11	2.39	2.26	< 2.0
1S	0.24	0.25	0.19	0.19	0.25	0.29	0.31	0.32	0.19
D2S	0.67	0.71	0.55	0.55	0.71	0.83	0.86	0.90	0.53
n/Outliers	214/4		221/6		210/11		199/18		

Test 2	2009		2010		2011		2012		ASTM C136[A]
P 19.0 mm	1.09	2.09	1.10	2.10	1.11	2.11	1.12	2.12	
Mean	98.9	98.9	95.8	96.0	96.5	96.2	95.0	93.7	95 - 85
1S	0.4	0.3	0.9	0.7	0.7	0.8	1.0	1.1	1.37
D2S	1.0	0.9	2.4	1.9	1.9	2.1	2.8	3.1	3.9
n/Outliers	212/6		227/0		215/7		215/2		

Test 3	2009		2010		2011		2012		ASTM C136[A]
P 16.0 mm	1.09	2.09	1.10	2.10	1.11	2.11	1.12	2.12	
Mean	94.8	94.8	89.3	89.8	86.4	85.3	90.2	87.6	95 - 85
1S	0.6	0.6	1.4	1.0	1.1	1.6	1.6	1.6	1.37
D2S	1.8	1.8	4.0	2.9	3.0	4.6	4.6	4.6	3.9
n/Outliers	215/3		224/3		208/14		211/5		

Test 4	2009		2010		2011		2012		ASTM C136[A]
P 13.2 mm	1.09	2.09	1.10	2.10	1.11	2.11	1.12	2.12	
Mean	90.7	90.8	82.8	83.6	76.2	74.4	85.4	82.0	85 - 80
1S	0.7	0.7	1.7	1.3	1.4	2.1	1.9	1.8	1.92
D2S	2.0	1.9	4.9	3.6	3.8	5.9	5.5	5.2	5.4
n/Outliers	210/8		226/1		214/8		209/8		

Test 5	2009		2010		2011		2012		ASTM C136[A]
P 9.5 mm	1.09	2.09	1.10	2.10	1.11	2.11	1.12	2.12	
Mean	83.7	83.9	71.5	72.4	62.0	59.6	75.8	71.5	80 – 60
1S	0.8	0.7	1.8	1.5	1.7	2.3	2.3	2.2	2.82
D2S	2.4	2.0	5.2	4.3	4.8	6.4	6.4	6.4	8.0
n/Outliers	208/10		226/1		215/7		210/7		

Test 6	2009		2010		2011		2012		ASTM C136[A]
P 4.75 mm	1.09	2.09	1.10	2.10	1.11	2.11	1.12	2.12	
Mean	72.3	72.6	53.4	54.2	46.5	44.0	58.1	53.8	60 – 20
1S	0.8	0.8	1.7	1.5	1.8	2.0	2.3	2.2	1.97
D2S	2.4	2.2	4.7	4.1	5.1	5.7	6.6	6.2	5.6
n/Outliers	208/10		224/3		211/11		207/10		

Test 8	2009		2010		2011		2012		ASTM C131	
L. A	1.09	2.09	1.10	2.10	1.11	2.11	1.12	2.12	C of V	σ^*
Mean	25.8	26.2	22.4	22.1	24.2	23.8	22.6	21.9	10-45	22.3
1S	1.37	1.71	1.43	1.21	1.02	1.40	1.32	1.34	4.5%	1.00
D2S	3.88	4.83	4.05	3.42	2.89	3.96	3.73	3.81	12.7%	2.84
n/Outliers	10/2		13/0		12/1		11/0			

A – AMRL reports percent passing inch series equivalent sieves.

σ^* - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Test 9	2009		2010		2011		2012		MTO LS-604
RD (O.D.)	1.09	2.09	1.10	2.10	1.11	2.11	1.12	2.12	
Mean	2.690	2.691	2.631	2.631	2.670	2.669	2.655	2.657	
1S	0.005	0.006	0.007	0.006	0.007	0.007	0.008	0.008	0.006
D2S	0.014	0.017	0.020	0.017	0.020	0.020	0.023	0.023	0.017
n/Outliers	97/9		105/6		96/11		102/3		

Test 10	2009		2010		2011		2012		MTO LS-604
ABS	1.09	2.09	1.10	2.10	1.11	2.11	1.12	2.12	
Mean	0.393	0.389	1.259	1.246	0.709	0.703	2.094	2.063	< 2%
1S	0.058	0.063	0.107	0.104	0.087	0.088	0.121	0.134	0.09
D2S	0.164	0.178	0.303	0.294	0.246	0.249	0.342	0.379	0.25
n/Outliers	95/11		109/2		101/6		102/3		

Test 11	2009		2010		2011		2012		ASTM C88	
$MgSO_4$	1.09	2.09	1.10	2.10	1.11	2.11	1.12	2.12	C of V	σ^*
Mean	8.9	9.0	5.9	5.5	15.1	14.9	26.1	25.3	9-20%	25.7
1S	2.7	2.0	1.9	1.6	2.9	2.2	5.4	5.3	25%	6.4
D2S	7.6	5.6	5.4	4.6	8.3	6.2	15.2	15.0	71%	18.2
n/Outliers	39/2		40/1		40/4		42/1			

Test 12	2009		2010		2011		2012		MTO LS-607
% Crush	1.09	2.09	1.10	2.10	1.11	2.11	1.12	2.12	
Mean	56.9	57.2	72.3	72.2	63.1	63.7	76.9	77.5	55% - 85%
1S	6.9	7.1	5.1	5.4	4.2	4.1	5.6	5.9	4.7
D2S	19.5	20.0	14.4	15.4	12.0	11.5	15.8	16.7	13.2
n/Outliers	215/3		206/21		202/20		201/15		

Test 13	2009		2010		2011		2012		MTO LS-608
% F & E	1.09	2.09	1.10	2.10	1.11	2.11	1.12	2.12	
Mean	5.5	5.2	7.1	6.7	2.4	2.5	3.7	3.6	2.0% - 9.5%
1S	2.3	2.1	2.6	2.4	1.2	1.3	1.8	1.9	2.3
D2S	6.5	6.0	7.3	6.7	3.3	3.5	5.1	5.3	6.4
n/Outliers	194/13		217/4		201/18		203/11		

Test 14	2009		2010		2011		2012		MTO LS-609
PN Conc.	1.09	2.09	1.10	2.10	1.11	2.11	1.12	2.12	
Mean	120.2	119.9	-	-	-	-	131.4	127.7	No Precision
1S	7.6	6.0	-	-	-	-	15.4	10.0	Statements for
D2S	21.5	17.0	-	-	-	-	43.3	24.7	this Test.
n/Outliers	25/2		28		28		28/8		

Test 16	2009		2010		2011		2012		MTO LS-618	
MDA, CA	1.09	2.09	1.10	2.10	1.11	2.11	1.12	2.12	C of V	σ
Mean	13.0	13.2	17.2	17.1	22.8	22.7	19.2	19.1	5-23%	19.1
1S	0.94	1.08	0.84	0.88	0.95	1.03	1.14	0.92	5.5%	1.05
D2S	2.66	3.06	2.37	2.49	2.70	2.91	3.23	2.59	15.4%	2.98
n/Outliers	66/4		69/5		70/7		72/5			

Test 17	2009		2010		2011		2012		MTO LS-614	
Freeze-thaw	1.09	2.09	1.10	2.10	1.11	2.11	1.12	2.12	C of V	σ
Mean	12.12	11.79	10.37	10.45	10.40	10.31	10.11	9.77	4-18%	9.94
1S	2.16	1.88	2.07	2.28	2.15	2.20	2.82	3.00	20.2%	2.01
D2S	6.11	5.32	5.85	6.46	6.09	6.21	8.00	8.51	57.1%	5.68
n/Outliers	51/4		53/4		55/2		58/1			

A – AMRL reports percent passing inch series equivalent sieves.

σ^* - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Test 20	2009		2010		2011		2012		ASTM C136[A]
P 2.36 mm	3.09	4.09	3.10	4.10	3.11	4.11	3.12	4.12	
Mean	63.4	63.5	38.5	39.0	37.4	35.6	43.2	40.3	60 - 20
1S	1.3	1.6	2.1	2.3	1.9	1.9	2.5	2.3	1.41
D2S	3.7	4.5	6.1	6.5	5.4	5.4	7.0	6.4	4.0
n/Outliers	202/16		216/11		219/3		203/14		

Test 21	2009		2010		2011		2012		ASTM C136[A]
P 1.18 mm	3.09	4.09	3.10	4.10	3.11	4.11	3.12	4.12	
Mean	52.5	52.6	26.4	26.8	30.1	28.7	30.2	28.5	60 - 20
1S	1.8	2.1	2.1	2.3	1.9	1.8	2.2	2.1	1.41
D2S	5.1	5.9	6.0	6.4	5.3	5.1	6.2	5.9	4.0
n/Outliers	203/15		216/11		219/3		205/12		

Test 22	2009		2010		2011		2012		ASTM C136[A]
P 600 μm	3.09	4.09	3.10	4.10	3.11	4.11	3.12	4.12	
Mean	37.9	37.8	18.0	18.3	22.0	21.0	22.0	21.0	60 - 20
1S	2.1	2.3	1.7	1.7	1.5	1.4	1.6	1.7	1.41
D2S	5.9	6.6	4.7	4.8	4.3	3.9	4.5	4.9	4.0
n/Outliers	204/14		215/12		216/6		201/16		

Test 23	2009		2010		2011		2012		ASTM C136[A]
P 300 μm	3.09	4.09	3.10	4.10	3.11	4.11	3.12	4.12	
Mean	19.6	19.7	12.9	13.1	12.6	12.2	16.5	16.0	20 - 15
1S	1.3	1.7	1.1	1.2	0.8	0.8	1.2	1.2	1.01
D2S	3.8	4.8	3.2	3.4	2.3	2.3	3.5	3.4	3.10
n/Outliers	206/12		215/12		214/8		199/18		

Test 24	2009		2010		2011		2012		ASTM C136[A]
P 150 μm	3.09	4.09	3.10	4.10	3.11	4.11	3.12	4.12	
Mean	9.7	9.8	10.3	10.5	8.1	7.8	12.3	12.0	15 - 10
1S	0.7	0.9	0.8	0.9	0.5	0.5	0.8	0.8	0.73
D2S	2.1	2.5	2.4	2.5	1.4	1.4	2.3	2.3	2.1
n/Outliers	209/9		214/13		206/16		198/19		

Test 25	2009		2010		2011		2012		ASTM C136[A]
P 75 μm	3.09	4.09	3.10	4.10	3.11	4.11	3.12	4.12	
Mean	5.9	6.0	8.5	8.7	6.0	5.8	9.1	8.8	10 - 2
1S	0.4	0.4	0.7	0.6	0.4	0.4	0.6	0.6	0.65
D2S	1.2	1.3	1.9	1.8	1.0	1.0	1.7	1.7	1.8
n/Outliers	203/15		213/14		206/16		200/17		

Test 27	2009		2010		2011		2012		MTO LS-605
RD (O.D.)	3.09	4.09	3.10	4.10	3.11	4.11	3.12	4.12	
Mean	2.686	2.687	2.615	2.614	2.654	2.654	2.647	2.649	
1S	0.009	0.010	0.015	0.016	0.010	0.011	0.011	0.009	0.012
D2S	0.025	0.028	0.042	0.045	0.028	0.031	0.031	0.025	0.034
n/Outliers	88/14		95/10		99/5		95/10		

Test 28	2009		2010		2011		2012		MTO LS-605
ABS	3.09	4.09	3.10	4.10	3.11	4.11	3.12	4.12	
Mean	0.940	0.940	1.499	1.516	0.700	0.684	1.171	1.148	< 2.0%
1S	0.13	0.13	0.19	0.20	0.12	0.12	0.15	0.16	0.16
D2S	0.38	0.37	0.53	0.57	0.34	0.34	0.44	0.46	0.45
n/Outliers	97/5		98/7		94/10		96/9		

A – AMRL reports percent passing inch series equivalent sieves.

$\dot{\sigma}$ - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Test 30	2009		2010		2011		2012		MTO LS-621
% ACP	1.09	2.09	1.10	2.10	1.11	2.11	1.12	2.12	
Mean	27.3	27.2	31.2	31.2	36.4	37.0	47.1	47.6	25% - 45%
1S	4.7	3.8	7.0	7.2	3.5	3.3	5.4	5.2	3.8
D2S	13.2	10.7	19.7	20.4	9.8	9.2	15.2	14.8	10.8
n/Outliers	203/14		223/4		214/7		205/11		

Test 31	2009		2010		2011		2012		MTO LS-623
MWD	3.09	4.09	3.10	4.10	3.11	4.11	1.12	2.12	
Mean	2.176	2.180	2.323	2.322	2.315	2.318	2.416	2.421	
1S	0.029	0.036	0.027	0.029	0.033	0.038	0.032	0.032	0.030
D2S	0.082	0.102	0.076	0.082	0.093	0.107	0.090	0.090	0.085
n/Outliers	150/8		149/12		150/10		133/14		

Test 32	2009		2010		2011		2012		MTO LS-623
MDD	3.09	4.09	3.10	4.10	3.11	4.11	1.12	2.12	
Mean	1.979	1.982	2.152	2.154	2.147	2.154	2.257	2.264	
1S	0.037	0.039	0.030	0.029	0.032	0.033	0.035	0.034	0.033
D2S	0.105	0.110	0.085	0.082	0.090	0.093	0.099	0.096	0.093
n/Outliers	155/3		152/9		146/14		140/7		

Test 33	2009		2010		2011		2012		MTO LS-623
OMC	3.09	4.09	3.10	4.10	3.11	4.11	1.12	2.12	
Mean	10.04	10.04	7.95	7.96	7.99	7.94	7.13	7.07	
1S	0.44	0.48	0.32	0.29	0.30	0.28	0.33	0.33	0.38
D2S	1.25	1.37	0.89	0.81	0.85	0.79	0.93	0.92	1.07
n/Outliers	153/5		144/17		141/19		144/3		

Test 34	2009		2010		2011		2012		MTO LS-619	
MDA, FA3	3.09	4.09	3.10	4.10	3.11	4.11	3.12	4.12	C of V	σ
Mean	13.2	13.2	15.5	15.5	10.7	10.7	17.6	17.7	7-18%	17.7
1S	1.1	1.2	1.1	1.1	0.8	0.9	1.1	1.1	7.7%	1.4
D2S	3.0	3.4	3.1	3.2	2.1	2.6	3.0	3.0	21.8%	3.9
n/Outliers	68/2		69/5		74/3		71/6			

Test 40	2009		2010		2011		2012		MTO LS-702
P 2.0 mm	5.09	6.09	5.10	6.10	5.11	6.11	5.12	6.12	
Mean	99.9	99.9	100	100	99.0	98.9	100	100	No MTO
1S					0.6	0.7			precision
D2S					1.7	1.8			statements for
n/Outliers	71/0		74/0		71/5		76/0		this test

Test 41	2009		2010		2011		2012		MTO LS-702
P 425 µm	5.09	6.09	5.10	6.10	5.11	6.11	5.12	6.12	
Mean	97.2	97.1	96.4	96.5	96.2	95.9	99.8	99.8	No MTO
1S	0.5	0.6	0.4	0.4	0.7	0.9	0.2	0.2	precision
D2S	1.5	1.7	1.1	1.0	2.1	2.7	0.5	0.5	statements for
n/Outliers	69/2		67/7		67/9		71/5		this test

Test 42	2009		2010		2011		2012		MTO LS-702
P 75 µm	5.09	6.09	5.10	6.10	5.11	6.11	5.12	6.12	
Mean	91.8	91.4	88.6	88.7	90.7	90.4	99.1	99.1	No MTO
1S	1.0	0.9	0.5	0.3	1.1	1.2	0.3	0.3	precision
D2S	2.9	2.6	1.3	1.0	3.1	3.5	1.0	1.0	statements for
n/Outliers	66/5		63/11		69/7		71/5		this test

A – AMRL reports percent passing inch series equivalent sieves.

$\dot{\sigma}$ - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Test 43	2009		2010		2011		2012		MTO LS-702
P 20 µm	5.09	6.09	5.10	6.10	5.11	6.11	5.12	6.12	
Mean	79.1	78.5	70.6	70.7	78.0	77.6	80.6	80.6	No MTO
1S	3.9	3.5	4.4	4.2	4.2	4.0	4.2	4.2	precision
D2S	11.0	10.0	12.5	12.0	12.0	11.4	12.0	12.0	statements for
n/Outliers	71/0		73/1		74/2		74/2		this test

Test 44	2009		2010		2011		2012		MTO LS-702
P 5 µm	5.09	6.09	5.10	6.10	5.11	6.11	5.12	6.12	
Mean	58.9	58.8	44.8	44.6	58.2	58.3	43.7	43.9	No MTO
1S	3.6	3.5	3.0	3.3	4.3	3.9	2.7	2.6	precision
D2S	10.1	9.9	8.5	9.4	12.1	11.0	7.7	7.2	statements for
n/Outliers	69/2		69/5		73/3		71/5		this test

Test 45	2009		2010		2011		2012		MTO LS-702
P 2 µm	5.09	6.09	5.10	6.10	5.11	6.11	5.12	6.12	
Mean	44.4	44.0	30.9	30.5	43.6	43.7	28.6	28.8	No MTO
1S	2.9	3.1	2.7	3.4	3.0	3.2	2.3	2.3	precision
D2S	8.3	8.8	7.8	9.6	8.5	9.1	6.6	6.6	statements for
n/Outliers	69/2		68/6		72/4		72/4		this test

Test 46	2009		2010		2011		2012		ASTM D4318
L. L	5.09	6.09	5.10	6.10	5.11	6.11	5.12	6.12	
Mean	36.9	36.7	27.0	27.2	36.6	36.7	32.2	32.2	33.3
1S	1.3	1.7	1.3	1.4	1.3	1.6	1.2	1.2	0.8
D2S	3.7	4.8	3.7	4.0	3.7	4.4	3.3	3.3	2
n/Outliers	79/6		84/6		88/6		89/6		

Test 47	2009		2010		2011		2012		ASTM D4318
P. L	5.09	6.09	5.10	6.10	5.11	6.11	5.12	6.12	
Mean	18.9	18.8	15.3	15.2	18.6	18.7	18.9	18.9	19.9
1S	1.2	1.3	1.0	1.1	1.4	1.3	1.1	1.1	1.3
D2S	3.5	3.7	2.8	3.0	3.9	3.7	3.1	3.1	4
n/Outliers	81/4		86/4		92/2		86/9		

Test 48	2009		2010		2011		2012		ASTM D4318
P. I	5.09	6.09	5.10	6.10	5.11	6.11	5.12	6.12	
Mean	17.9	17.8	11.8	11.9	17.9	17.9	13.3	13.4	13.4
1S	1.9	2.0	1.4	1.5	1.6	1.6	1.7	1.7	1.6
D2S	5.5	5.8	4.0	4.4	4.6	4.6	4.8	4.8	4
n/Outliers	84/1		86/4		89/5		93/2		

Test 49	2009		2010		2011		2012		AASHTO T 100
SG of Soils	5.09	6.09	5.10	6.10	5.11	6.11	5.12	6.12	
Mean	2.734	2.735	2.729	2.729	2.734	2.734	2.721	2.718	
1S	0.031	0.029	0.026	0.029	0.032	0.034	0.023	0.023	0.04
D2S	0.088	0.082	0.074	0.082	0.090	0.096	0.065	0.065	0.11
n/Outliers	54/6		58/7		63/5		60/10		

A – AMRL reports percent passing inch series equivalent sieves.

$\dot{\sigma}$ - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Test 95	2009		2010		2011		2012		ASTM C1252
UC Void	3.09	4.09	3.10	4.10	3.11	4.11	3.12	4.12	
Mean	41.97	41.92	43.02	43.00	40.87	40.87	44.0	44.1	ASTM C1252[A]
1S	0.68	0.56	0.77	0.67	0.71	0.54	0.66	0.63	0.33%
D2S	1.92	1.58	2.18	1.90	2.00	1.53	1.86	1.78	0.93%
n/Outliers	59/4		58/8		59/7		66/5		

Test 96	2009		2010		2011		2012		ASTM D2419
SE Value	3.09	4.09	3.10	4.10	3.11	4.11	3.12	4.12	
Mean	69.4	68.7	35.8	35.7	36.8	35.8	32.5	32.0	< 80
1S	5.12	5.33	7.60	7.50	3.81	4.29	3.62	3.67	8.0
D2S	14.48	15.09	21.43	21.36	10.79	12.15	10.24	10.38	22.6
n/Outliers	58/1		60/2		56/7		65/2		

Test 97	2009		2010		2011		2012		ASTM D5821
% Fractured	1.09	2.09	1.10	2.10	1.11	2.11	1.12	2.12	
Mean	58.3	58.8	74.6	75.1	63.6	64.2	78.5	78.8	76.0%
1S	6.8	6.8	3.8	3.8	4.9	5.4	5.4	6.4	5.2%
D2S	19.4	19.3	10.8	10.7	13.8	15.3	15.4	18.1	14.7%
n/Outliers	61/3		67/3		69/2		70/2		

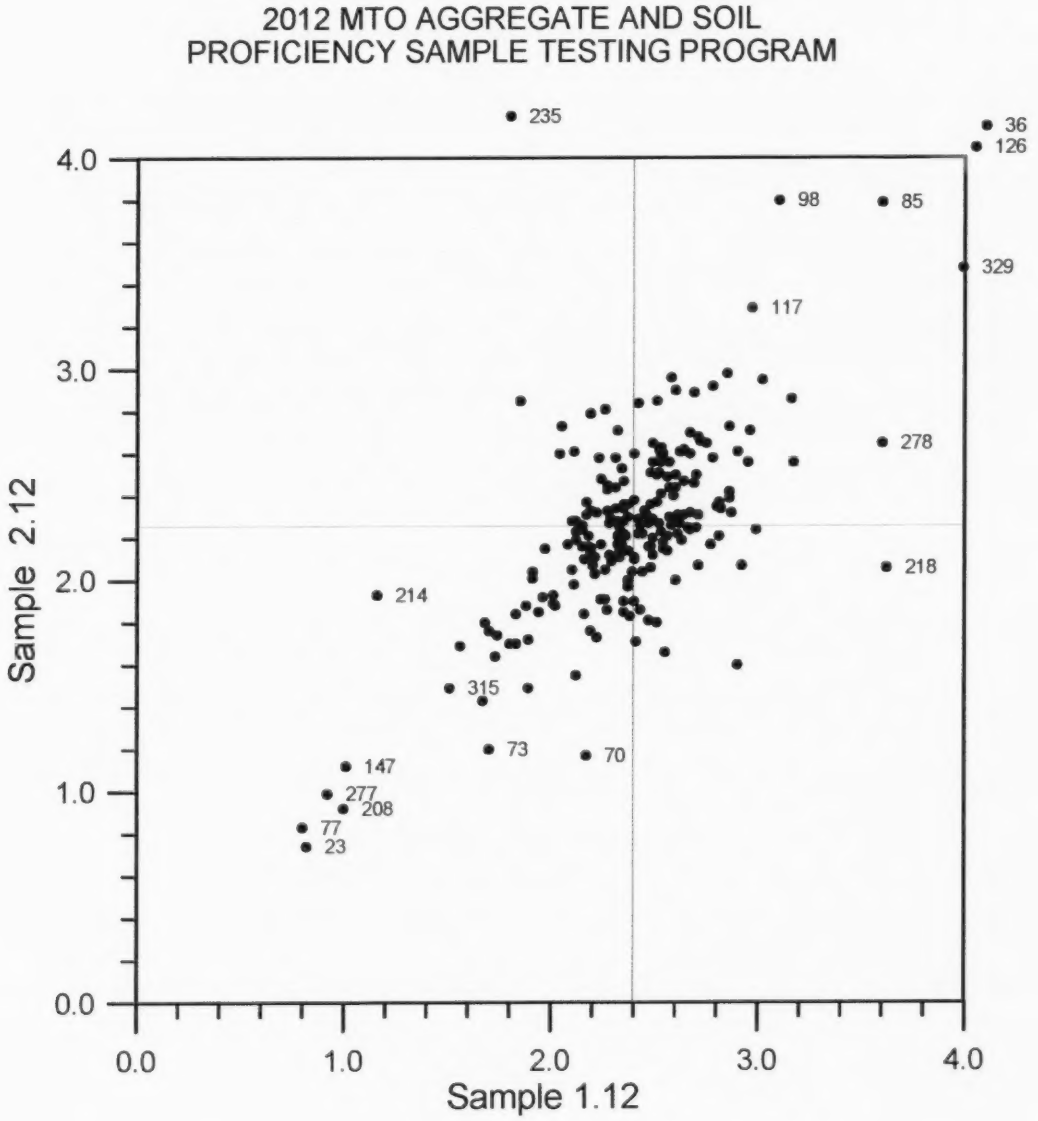
Test 99	2009		2010		2011		2012		ASTM D4791
% F & E	1.09	2.09	1.10	2.10	1.11	2.11	1.12	2.12	
Mean	1.10	1.02	1.57	1.37	0.24	0.31	0.66	0.55	19.0 -12.5 mm
1S	0.68	0.67	0.83	0.71	0.19	0.26	0.46	0.32	88.5%
D2S	1.92	1.90	2.35	2.00	0.53	0.73	1.30	0.89	250.3%
n/Outliers	60/6		69/3		65/7		66/6		

Test 123	2009		2010		2011		2012		ASTM C1260
Mortar Bar	1.09	2.09	1.10	2.10	1.11	2.11	1.12	2.12	
Mean	Not		0.191	0.373	Not		Not		Expansion >0.1%
1S	Conducted		0.028	0.045	Conducted		Conducted		15.2%
D2S			0.079	0.127					43%
n/Outliers			19/1						

A – AMRL reports percent passing inch series equivalent sieves.

$\sigma^{'}$ - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Appendix D1: Scatter Diagrams



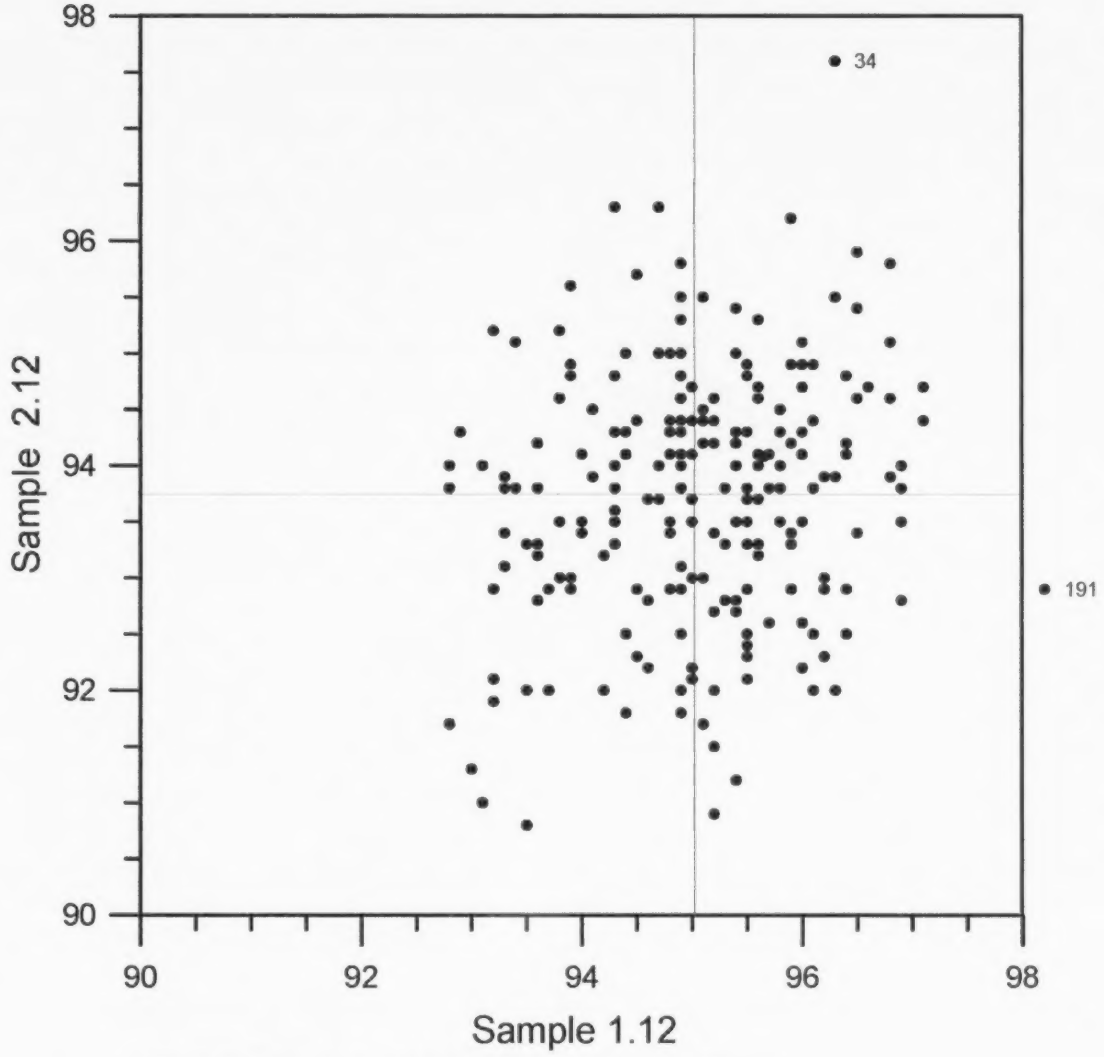
Test 1: Wash Pass 75 um

	Mat 1	Mat 2
Mean	2.395	2.256
Median	2.365	2.205
Std Dev	0.305	0.317

n = 199

Labs Eliminated: 23; 36; 70; 73; 77; 85; 98; 117; 126; 147; 208; 214; 218; 235; 277; 278; 315; 329

2012 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



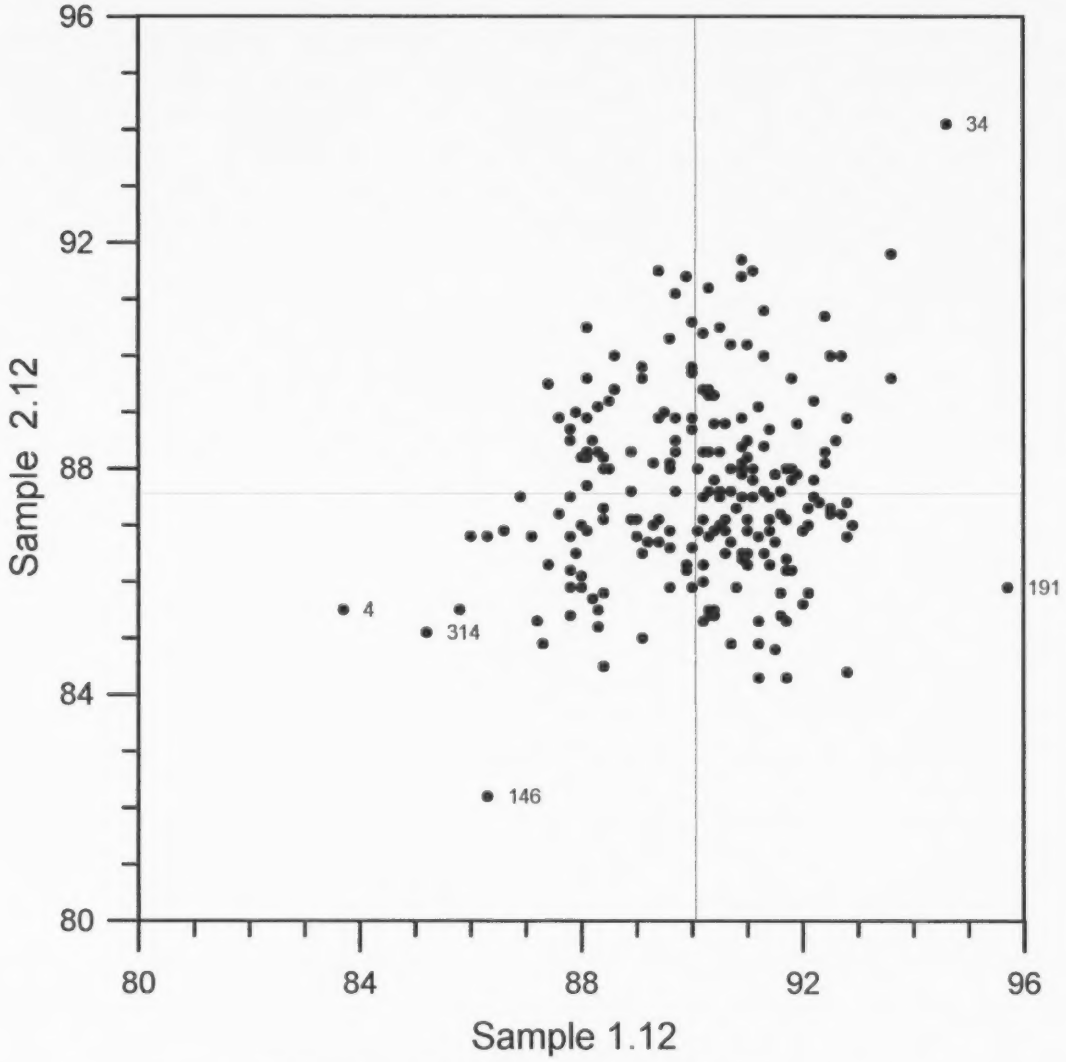
Test 2: Percent Passing the 19.0 mm Sieve

	Mat 1	Mat 2
Mean	95.059	93.726
Median	94.950	93.550
Std Dev	0.992	1.086

n = 215

Lab Eliminated: 34; 191

2012 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



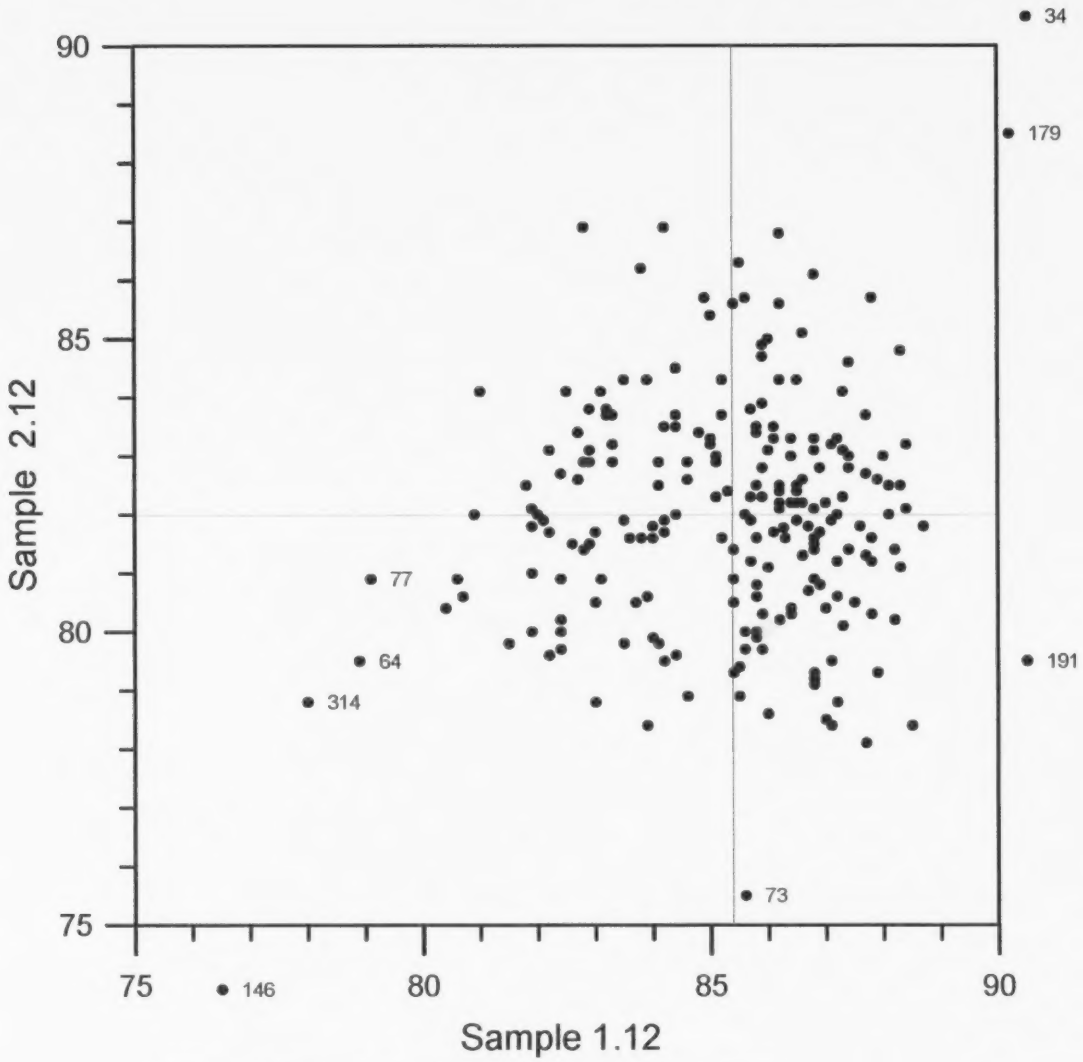
Test 3: Percent Passing the 16.0 mm Sieve

	Mat 1	Mat 2
Mean	90.163	87.640
Median	89.700	88.050
Std Dev	1.631	1.611

n = 211

Lab Eliminated: 4; 34; 146; 191; 314

2012 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



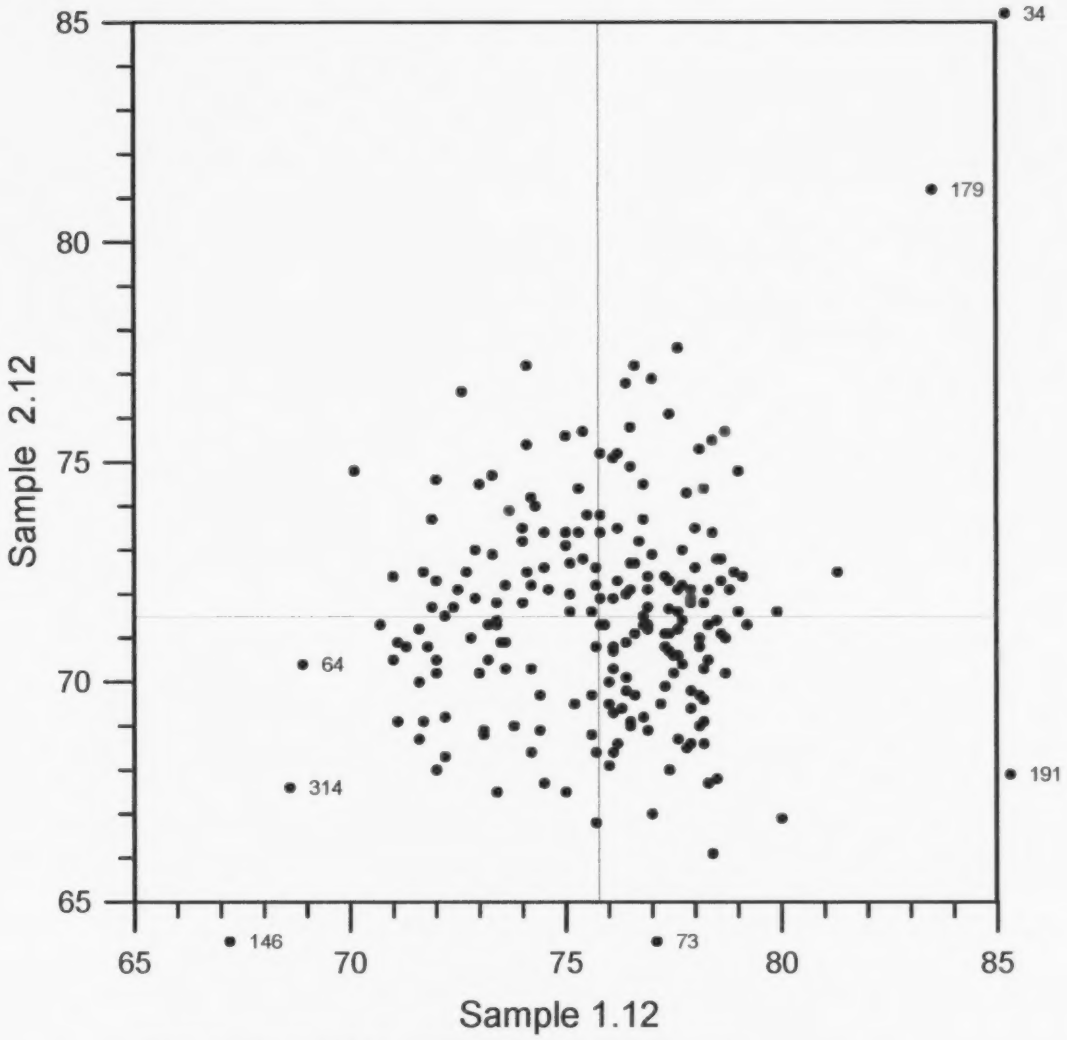
Test 4: Percent Passing the 13.20 mm Sieve

	Mat 1	Mat 2
Mean	85.363	82.006
Median	84.550	82.500
Std Dev	1.941	1.839

n = 209

Lab Eliminated: 34; 64; 73; 77; 146; 179; 191; 314

2012 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



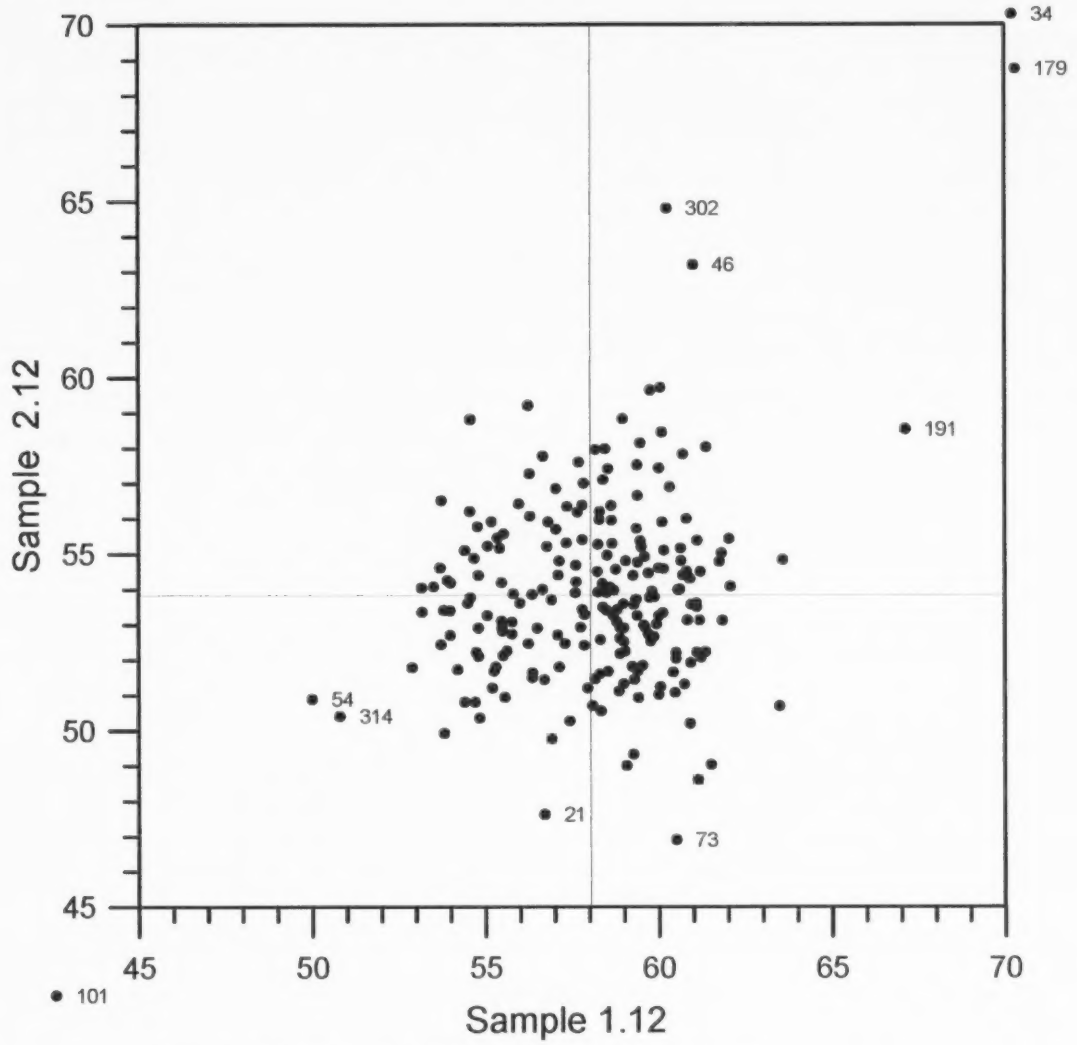
Test 5: Percent Passing the 9.5 mm Sieve

	Mat 1	Mat 2
Mean	75.786	71.506
Median	75.700	71.850
Std Dev	2.265	2.252

n = 210

Labs Eliminated: 34; 64; 73; 146; 179; 191; 314

2012 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



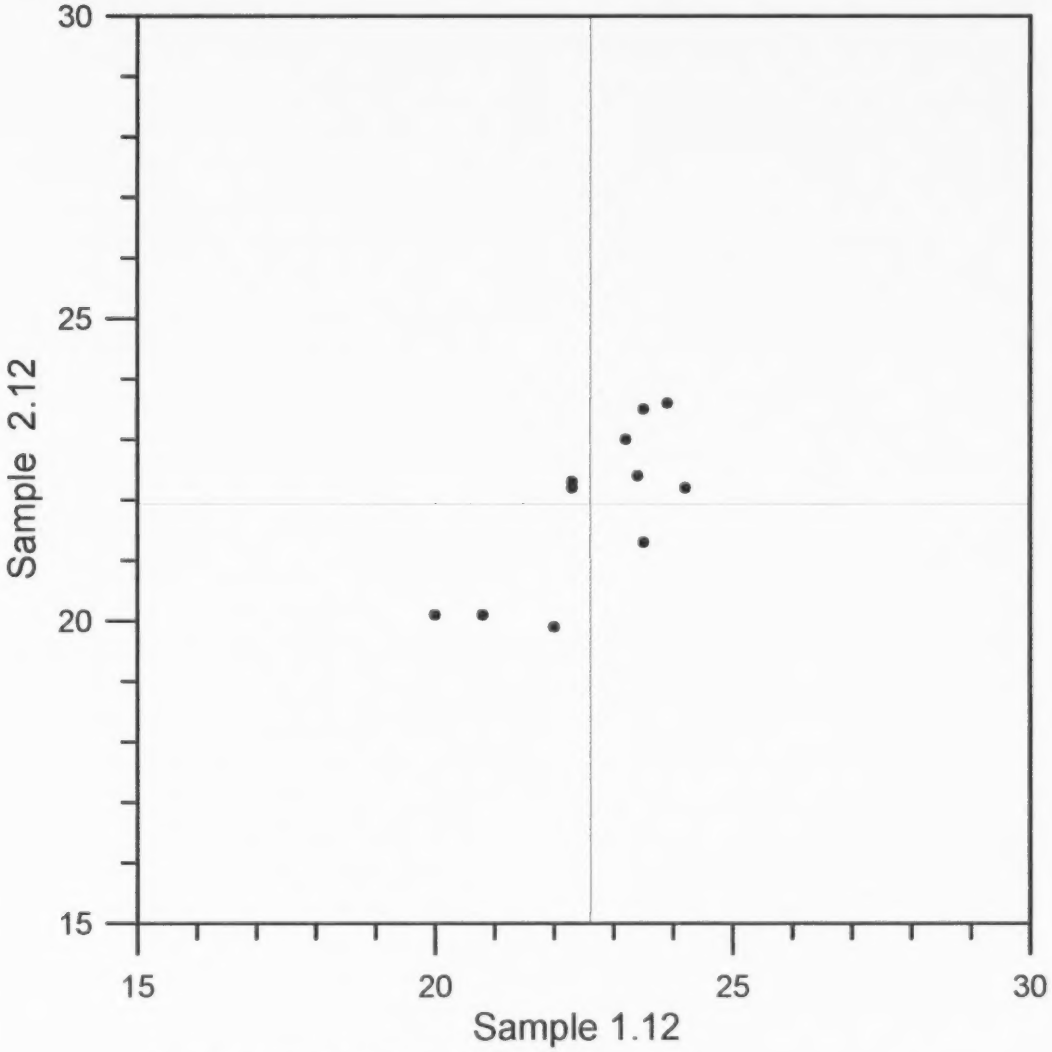
Test 6: Percent Passing the 4.75 mm Sieve

	Mat 1	Mat 2
Mean	58.115	53.832
Median	58.235	54.160
Std Dev	2.328	2.190

n = 207

Lab Eliminated: 21; 34; 46; 54; 73; 101; 179; 191; 302; 314

2012 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



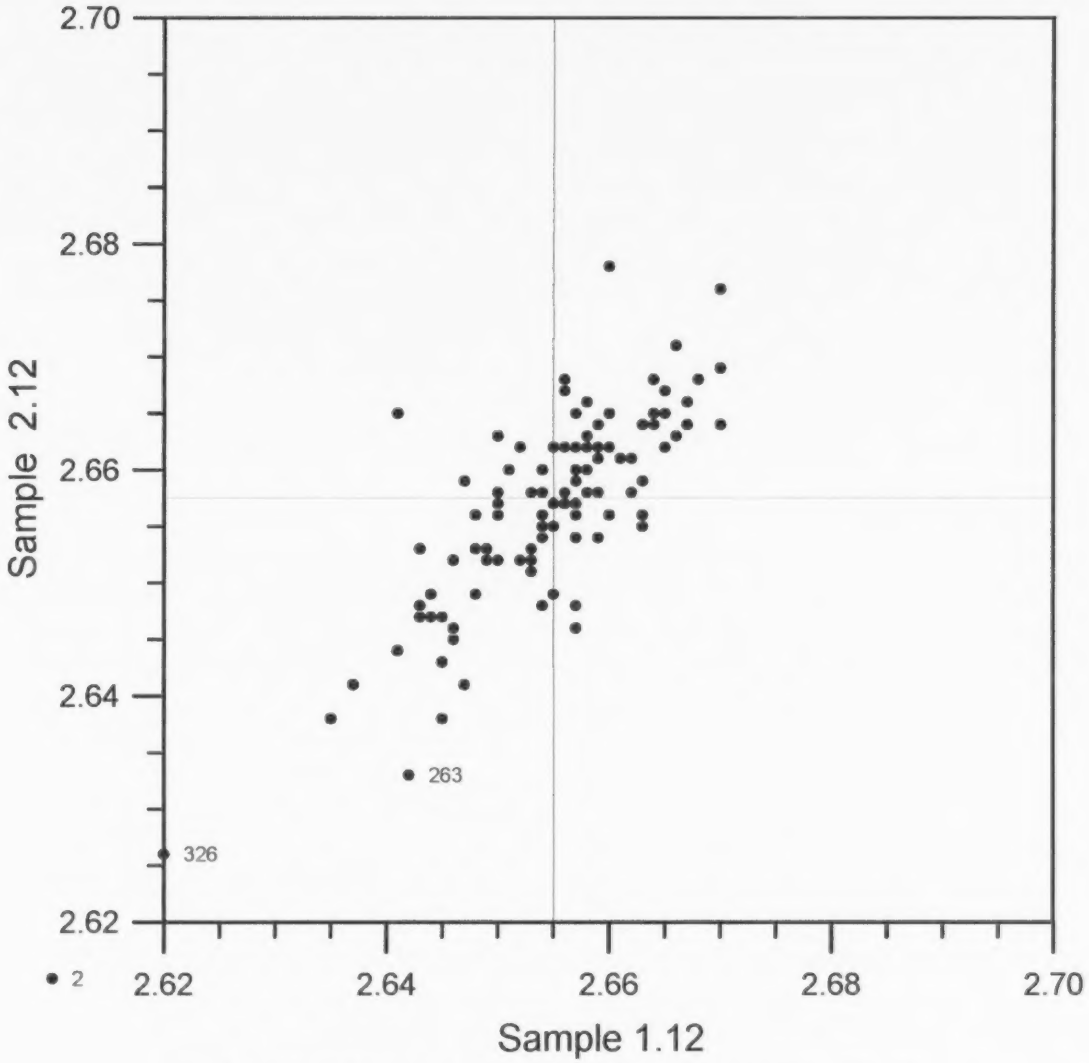
Test 8: Los Angeles Abrasion Loss, %

	Mat 1	Mat 2
Mean	22.645	21.873
Median	22.100	21.750
Std Dev	1.317	1.345

n = 11

Labs Eliminated: None

2012 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



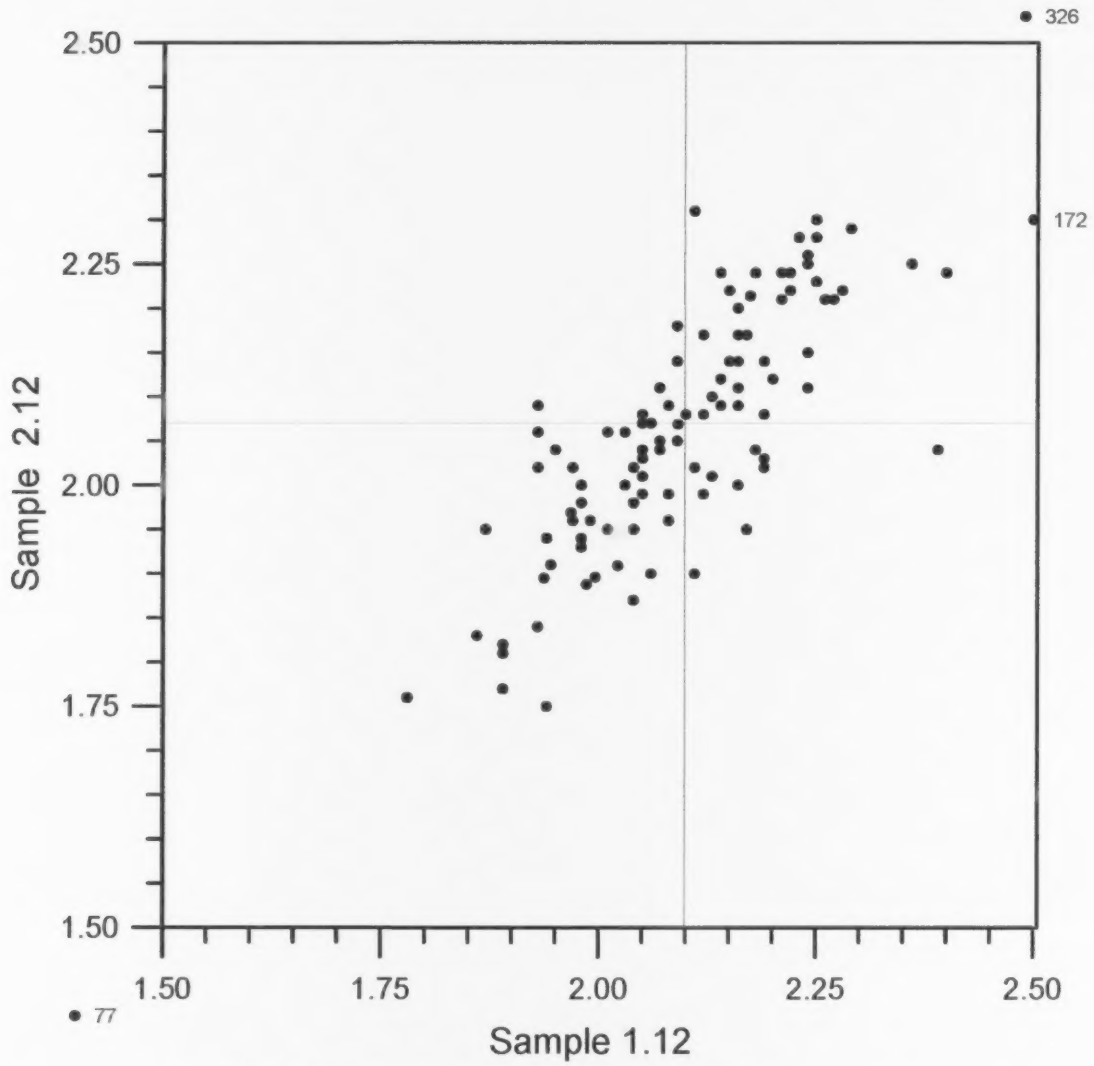
Test 9: Relative Density of Coarse Aggregate (O. D)

	Mat 1	Mat 2
Mean	2.655	2.657
Median	2.653	2.658
Std Dev	0.008	0.008

n = 102

Labs Eliminated: 2; 263; 326

2012 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



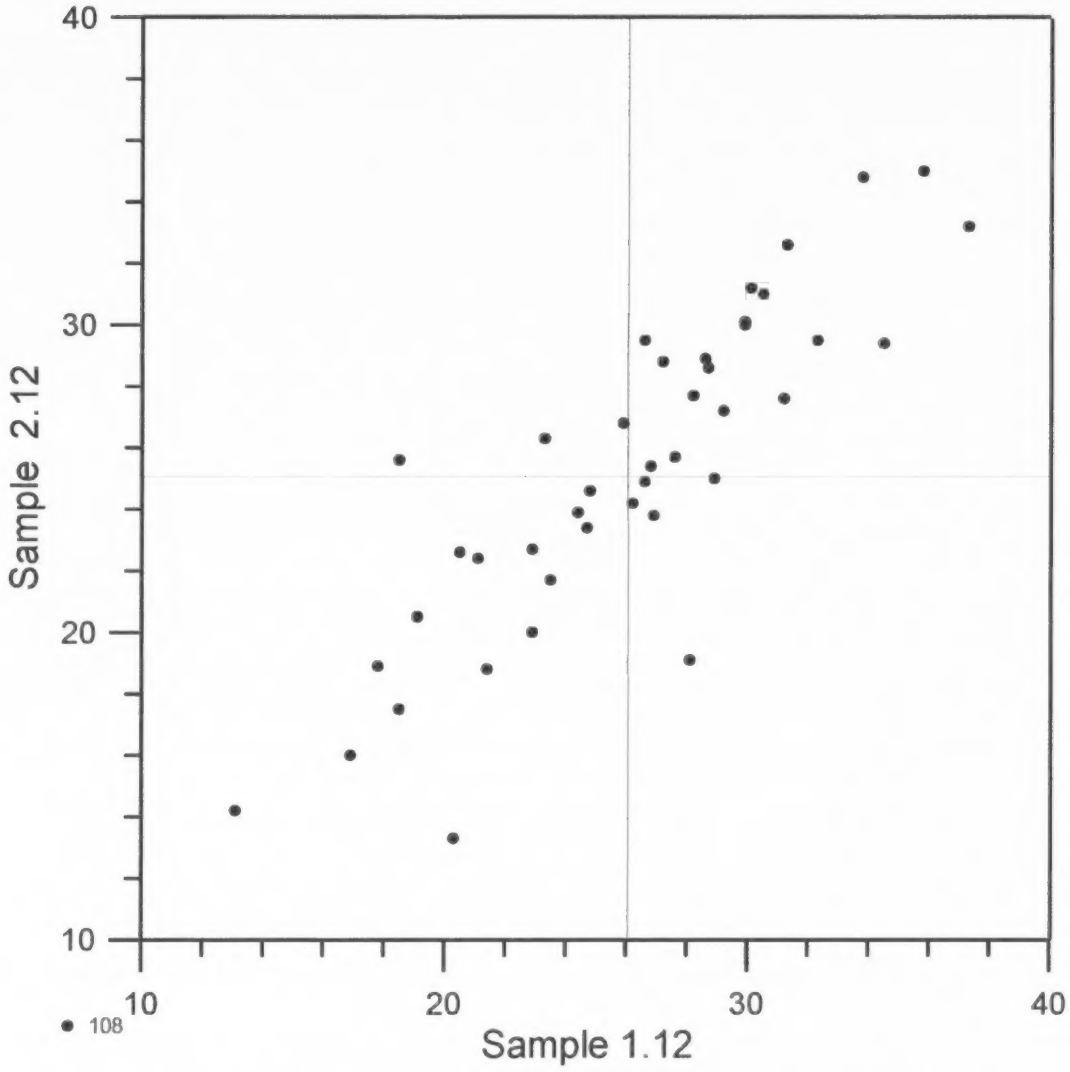
Test 10: Absorption of Coarse Aggregate

	Mat 1	Mat 2
Mean	2.094	2.063
Median	2.090	2.030
Std Dev	0.121	0.134

n = 102

Labs Eliminated: 77; 172; 326

2012 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



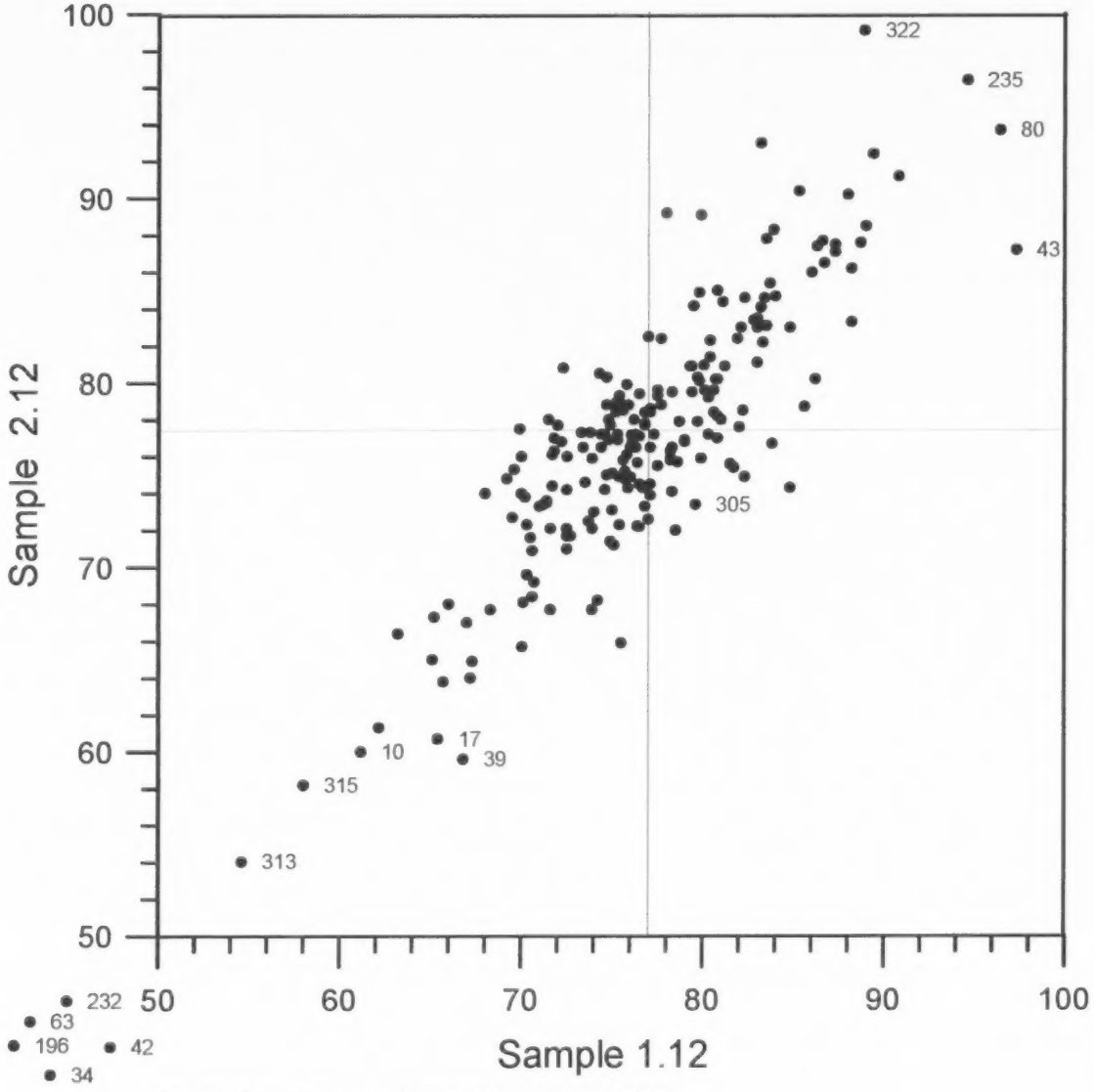
Test 11: MgSO4 Soundness of Coarse Aggregate, % Loss

	Mat 1	Mat 2
Mean	26.090	25.295
Median	25.200	24.150
Std Dev	5.387	5.300

n = 42

Lab Eliminated: 108

2012 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



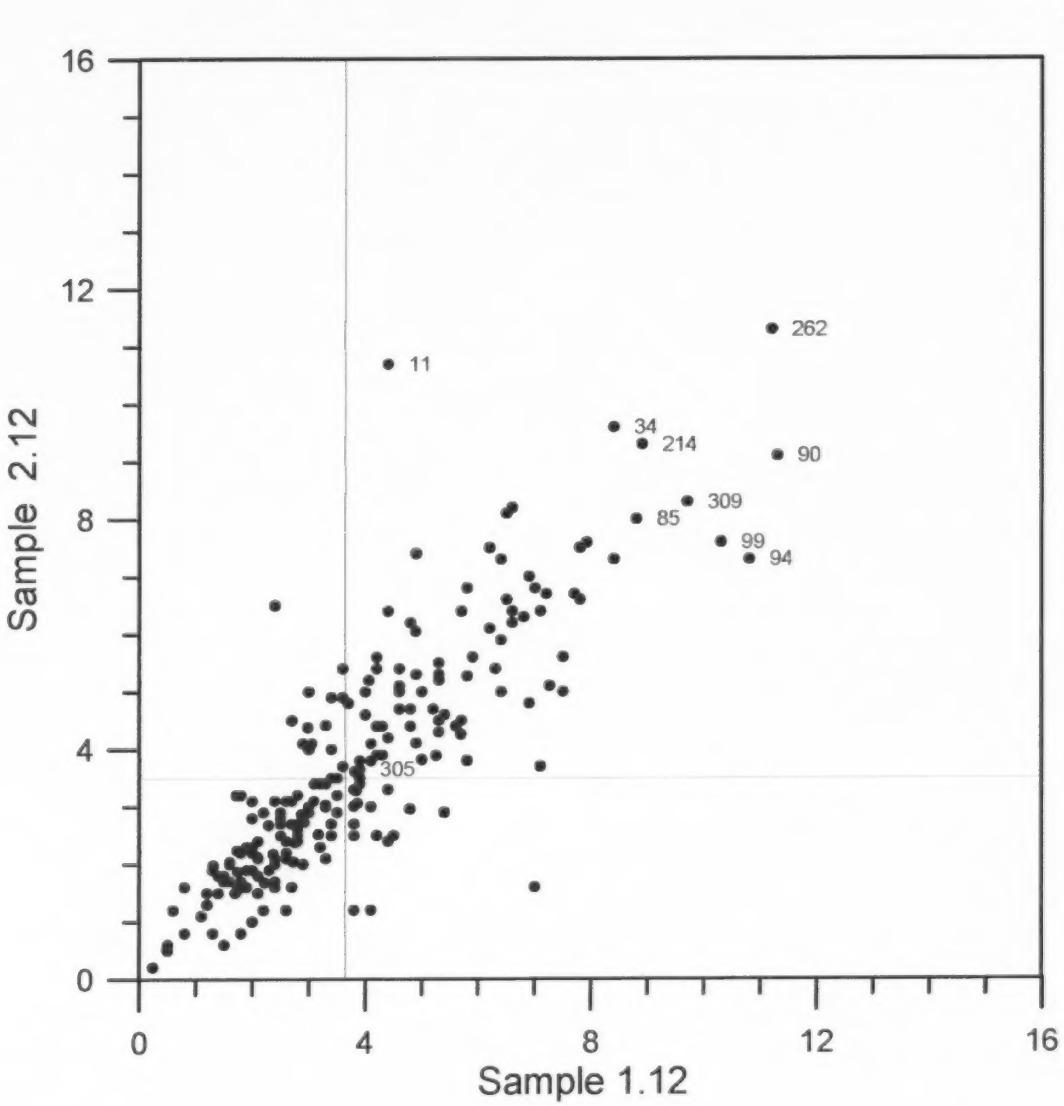
Test 12: Percent Crushed Particles

	Mat 1	Mat 2
Mean	76.931	77.495
Median	76.480	77.160
Std Dev	5.575	5.903

n = 201

Labs Eliminated: 10; 17; 34; 39; 42; 43; 63; 80; 196; 232; 235; 305; 313; 315; 322

2012 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



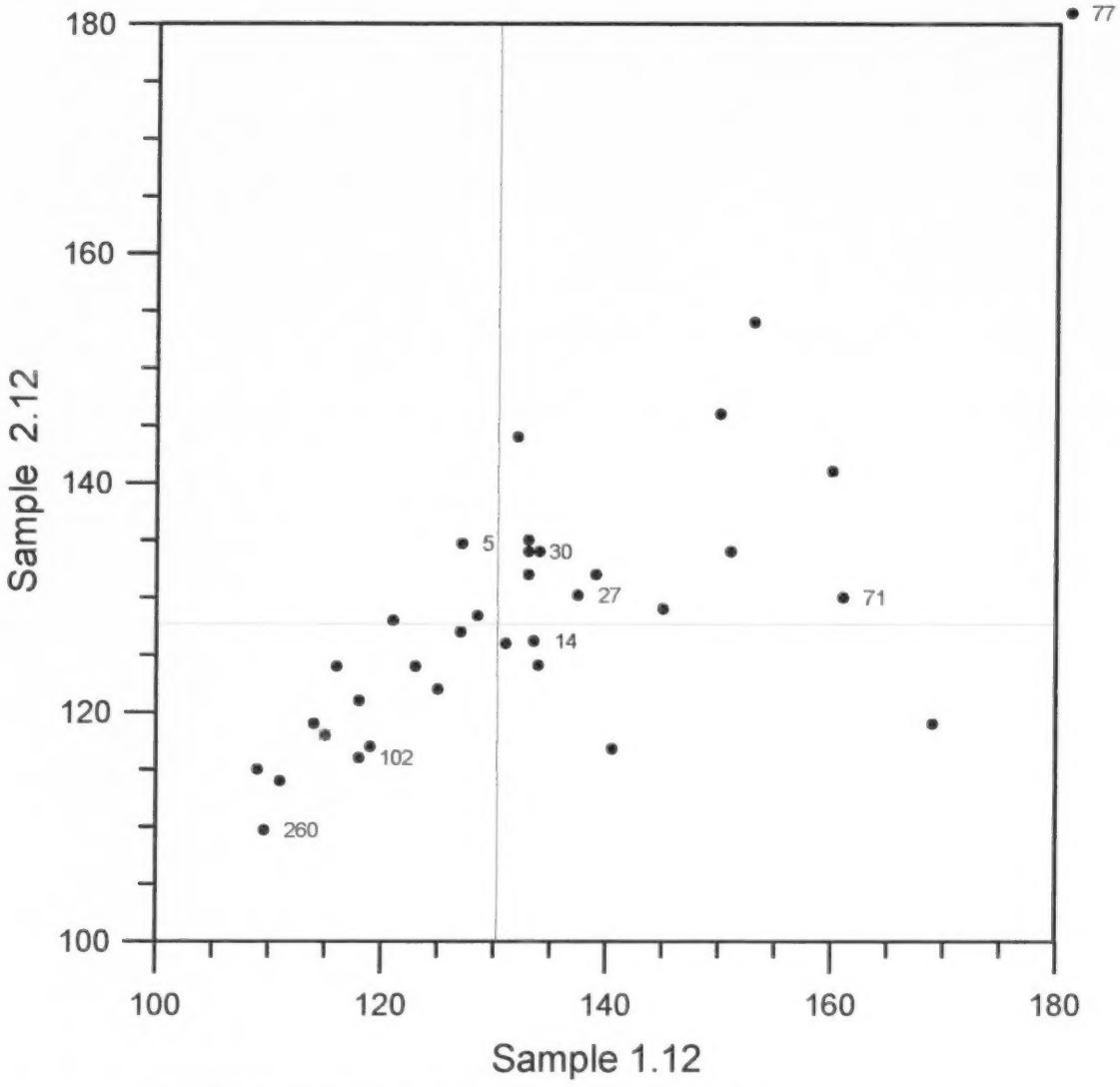
Test 13: Percent Flat and Elongated Particles

	Mat 1	Mat 2
Mean	3.672	3.614
Median	4.320	4.205
Std Dev	1.799	1.858

n = 203

Labs Eliminated: 11; 34; 60; 85; 90; 94; 99; 214; 262; 305; 309

2012 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



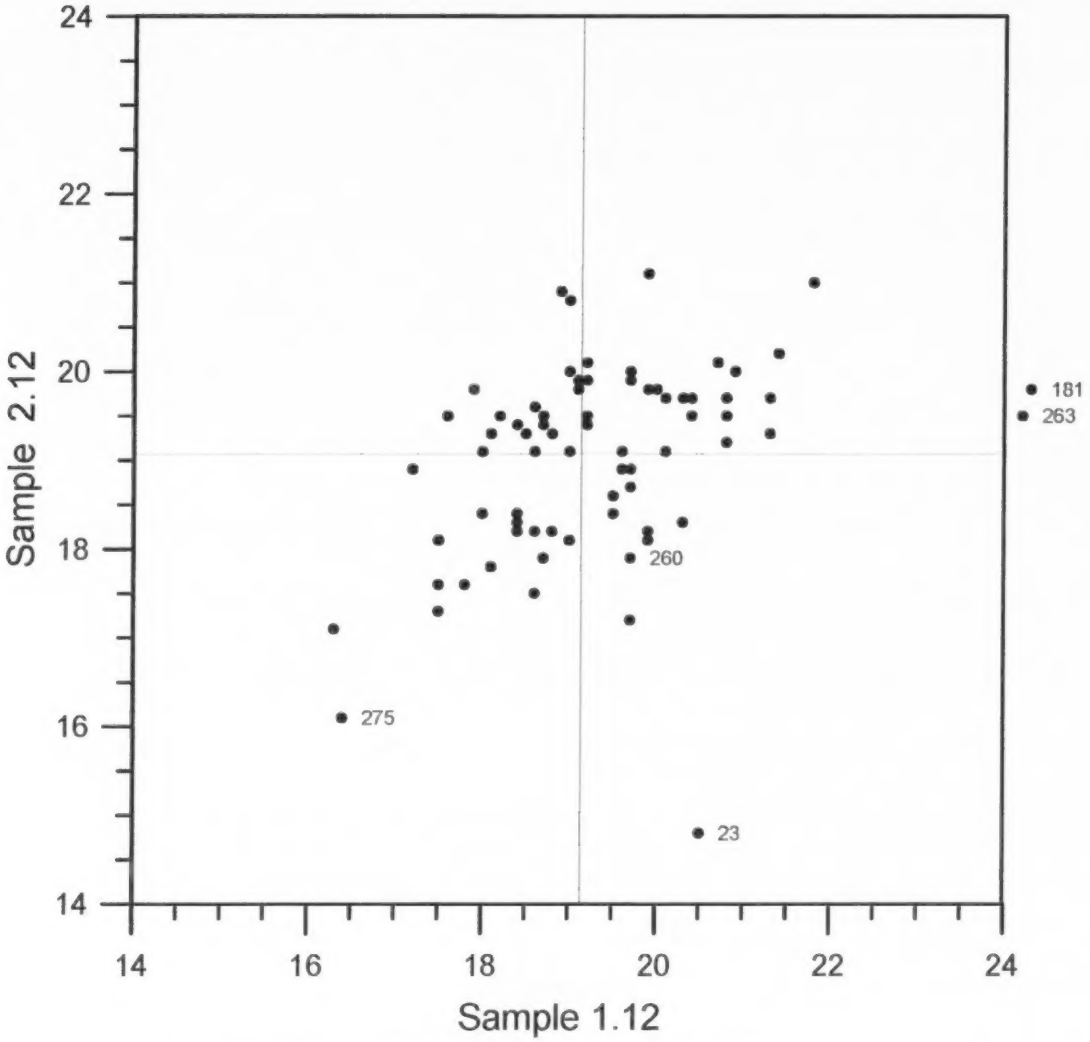
Test 14: Petrographic Number (Concrete)

	Mat 1	Mat 2
Mean	131.4	127.7
Median	139.0	134.0
Std Dev	15.4	10.0

n = 28

Lab Eliminated: 5; 14; 27; 30; 71; 77; 102; 260

2012 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



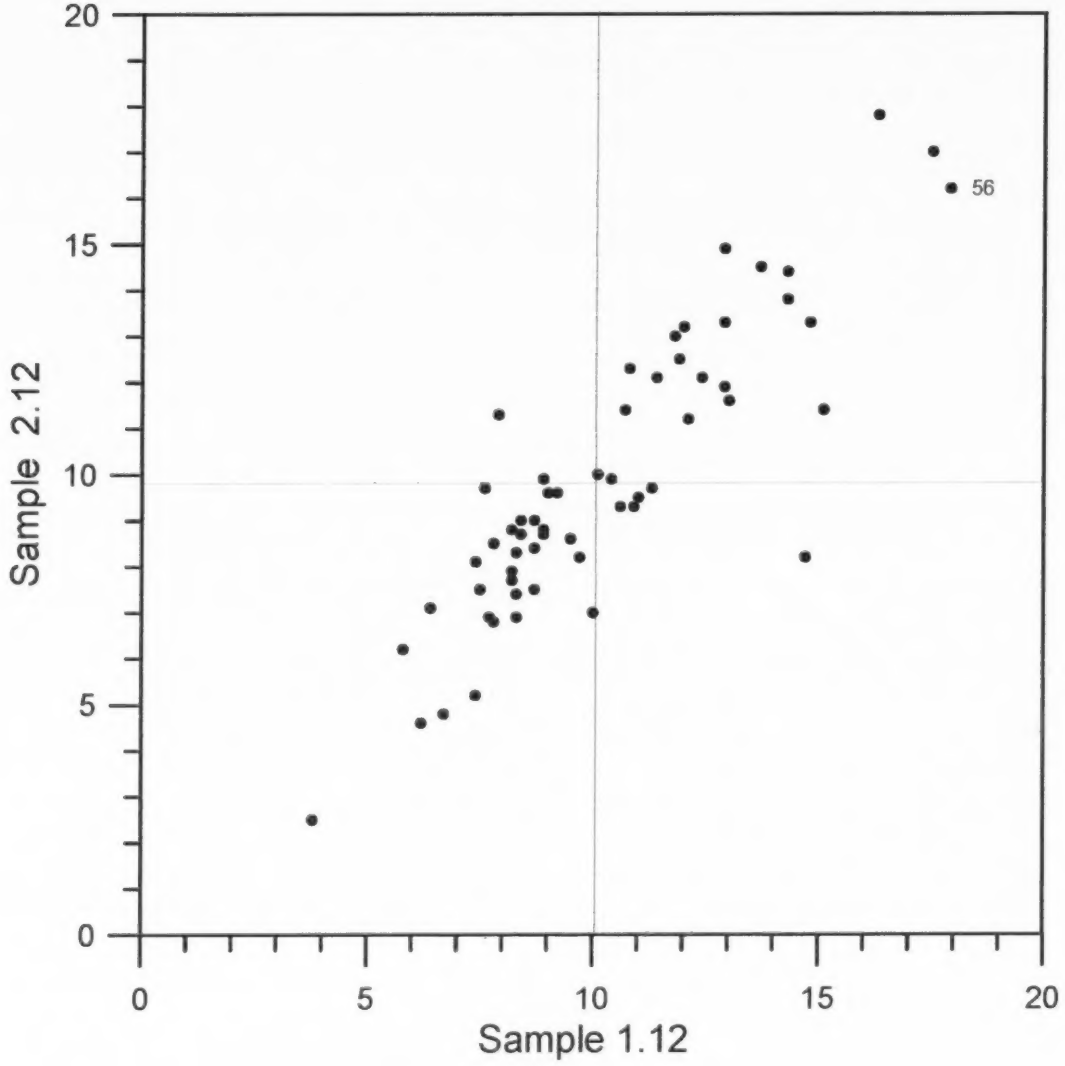
Test 16: Micro-Deval Abrasion Loss (CA), %

	Mat 1	Mat 2
Mean	19.169	19.112
Median	19.050	19.100
Std Dev	1.143	0.917

n = 72

Labs eliminated: 23; 181; 260; 263; 275

2012 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



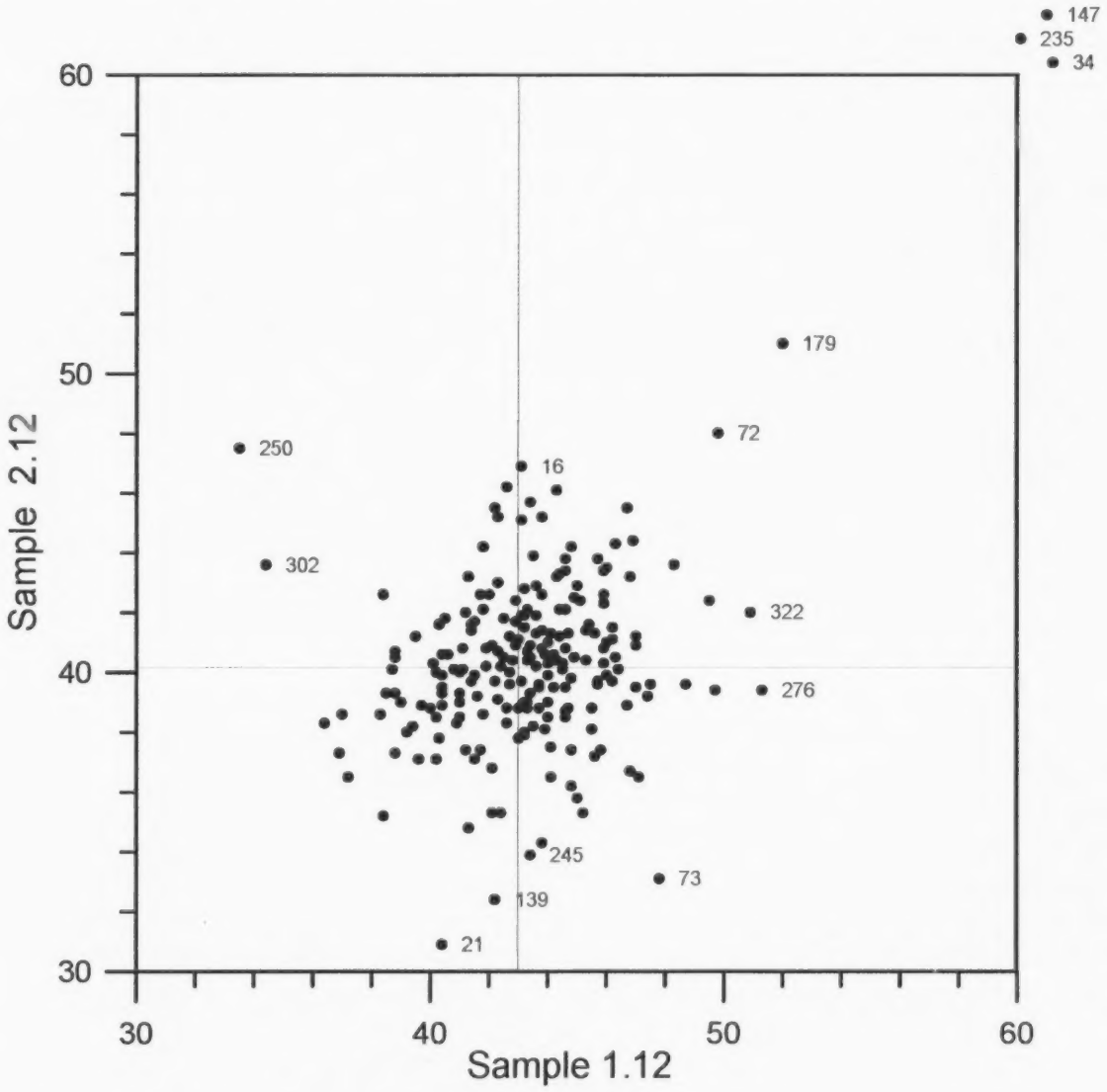
Test 17: Freeze-Thaw Loss, %

	Mat 1	Mat 2
Mean	10.109	9.772
Median	10.650	10.150
Std Dev	2.819	3.006

n = 58

Lab eliminated: 56

2012 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



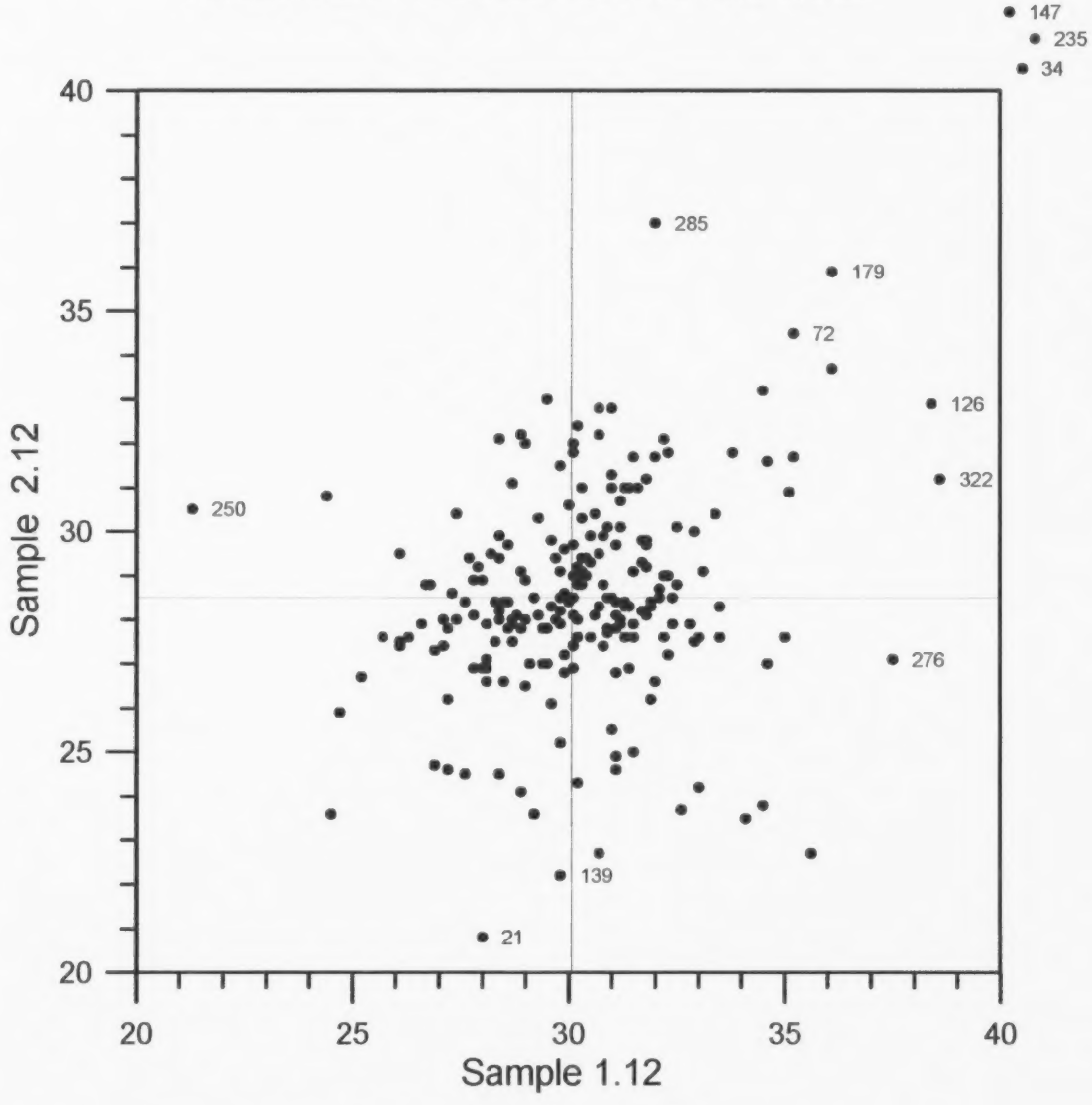
Test 20: Percent Passing the 2.36 mm Sieve

	Mat 1	Mat 2
Mean	43.215	40.324
Median	43.050	40.250
Std Dev	2.483	2.270

n = 203

Labs Eliminated: 16; 21; 34; 72; 73; 139; 147; 179; 235; 245; 250; 276; 302; 322

2012 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



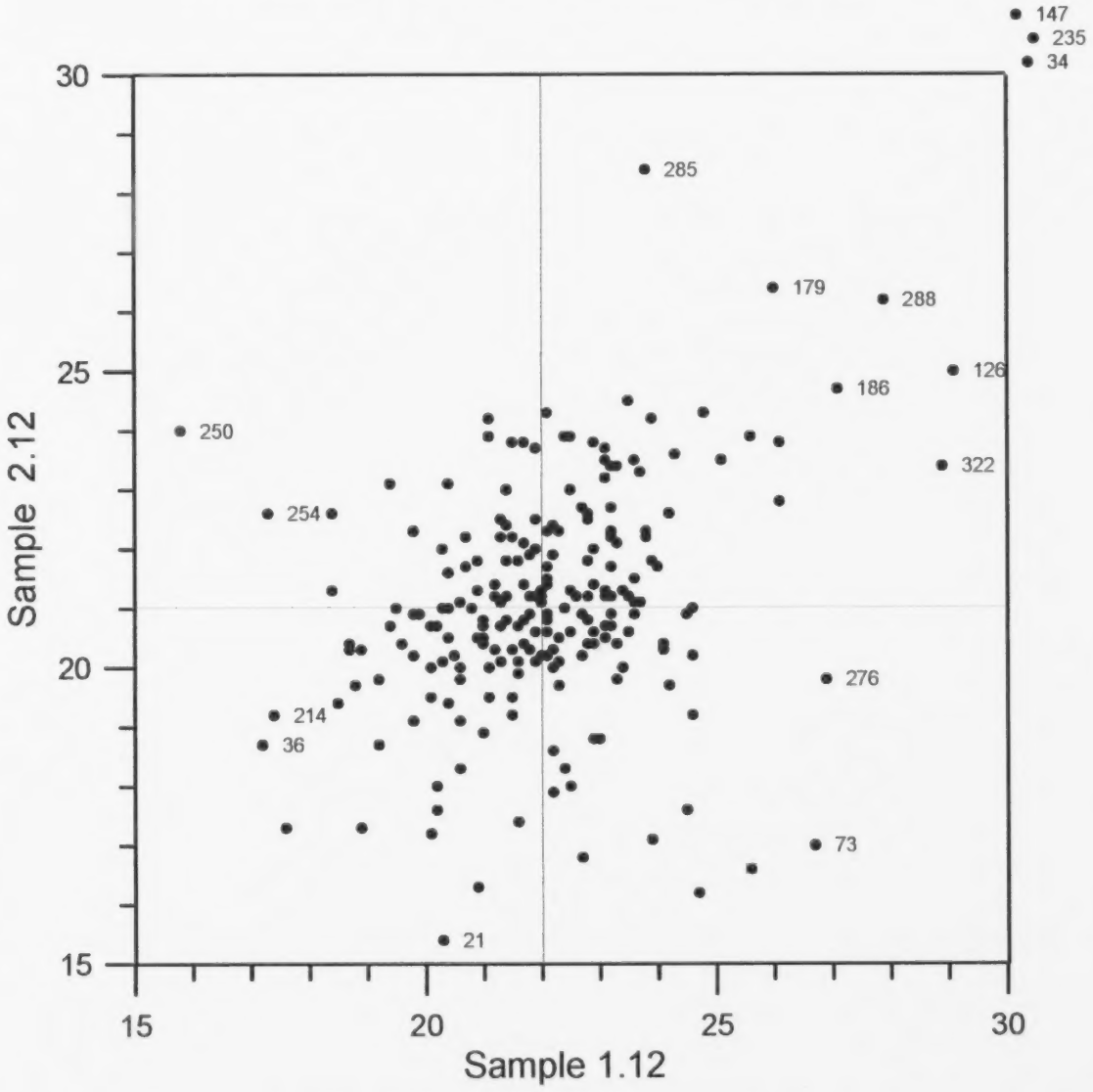
Test 21: Percent Passing the 1.18 mm Sieve

	Mat 1	Mat 2
Mean	30.203	28.488
Median	30.250	28.200
Std Dev	2.193	2.099

n = 205

Labs Eliminated: 21; 34; 72; 126; 139; 147; 179; 235; 250; 276; 285; 322

2012 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



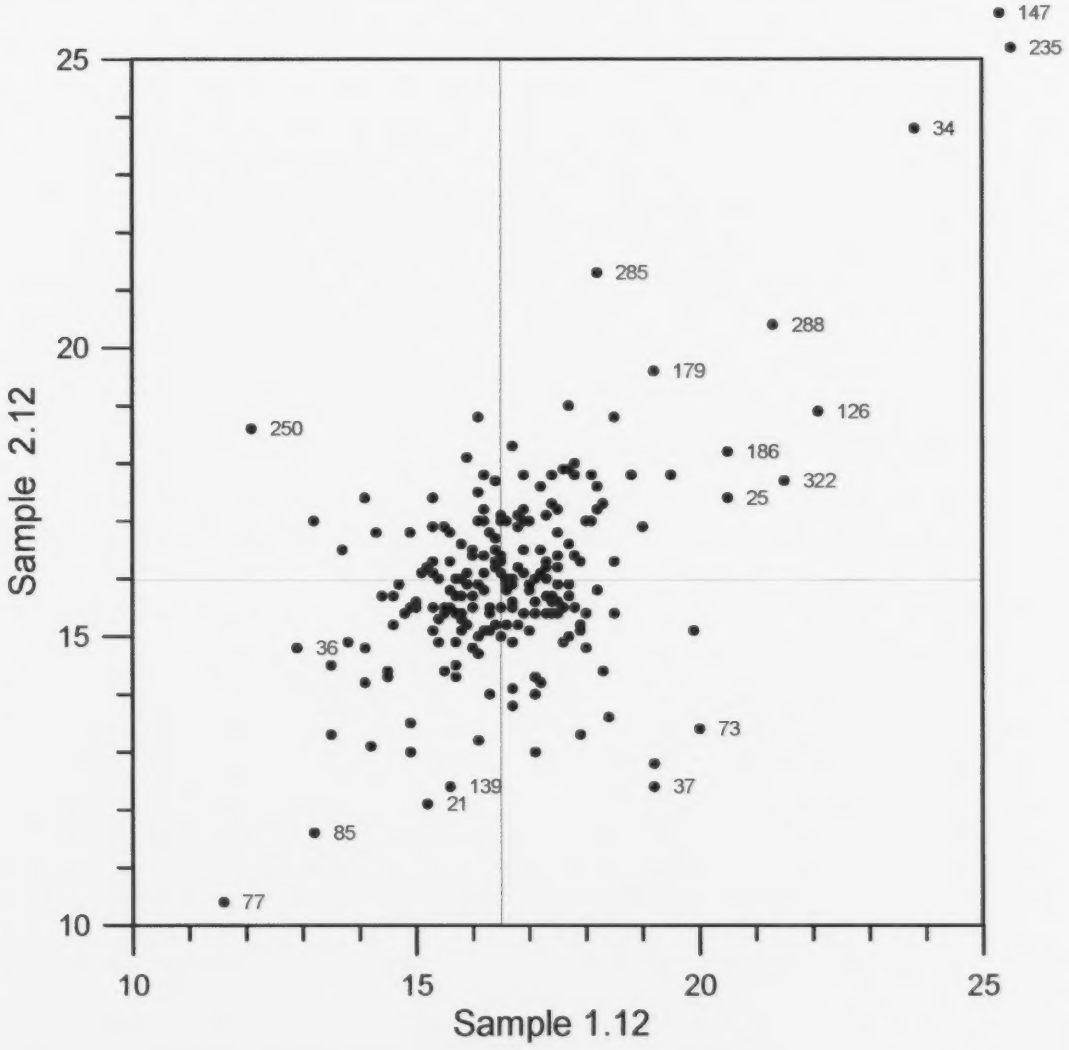
Test 22: Percent Passing the 600 um Sieve

	Mat 1	Mat 2
Mean	22.014	21.015
Median	21.850	20.350
Std Dev	1.601	1.742

n = 201

Lab Eliminated: 21; 34; 36; 73; 126; 147; 179; 186; 214; 235; 250; 254; 276; 285; 288; 322

2012 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



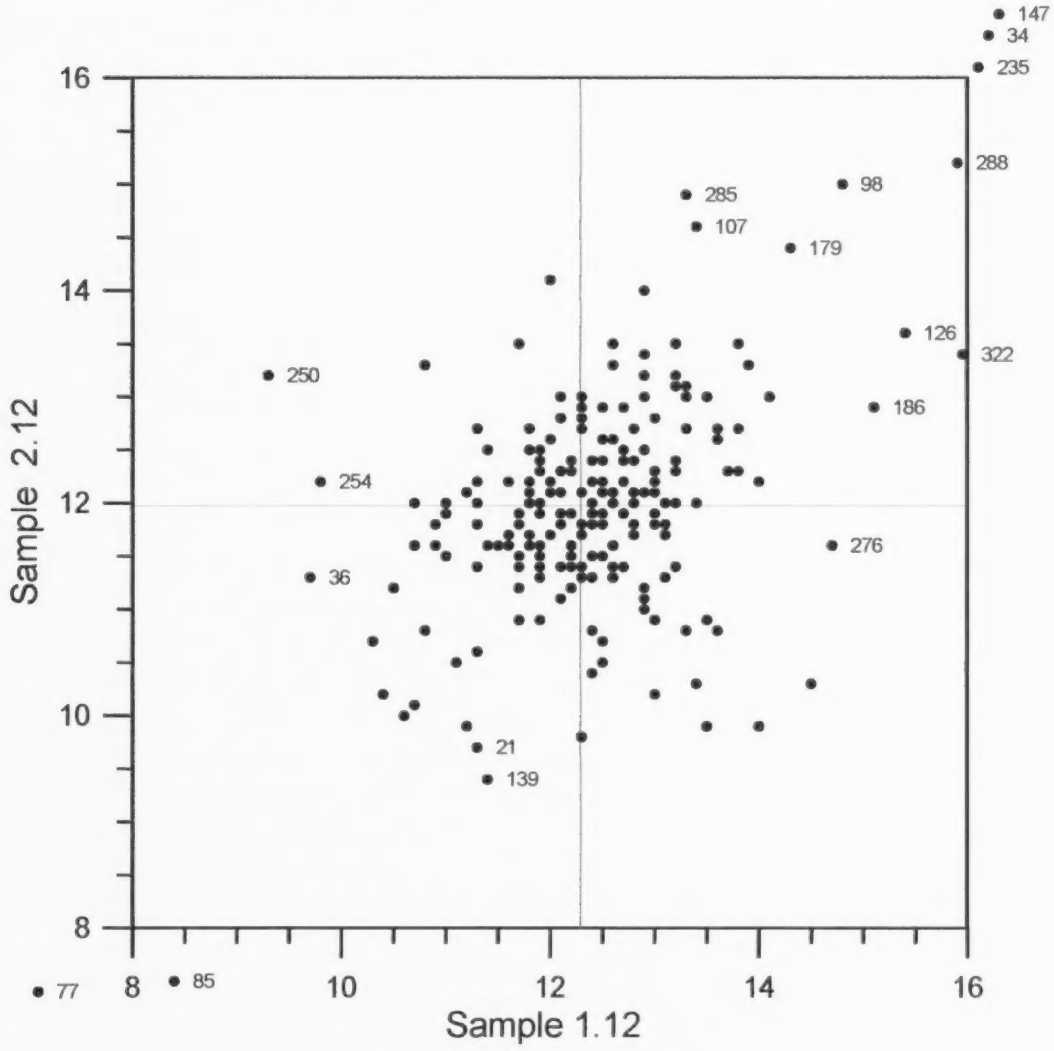
Test 23: Percent Passing the 300 um Sieve

	Mat 1	Mat 2
Mean	16.500	15.951
Median	16.550	15.900
Std Dev	1.237	1.206

n = 199

Lab Eliminated: 21; 25; 34; 36; 37; 73; 77; 85; 126; 139; 147; 179; 186; 235; 250; 285; 288; 322

2012 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



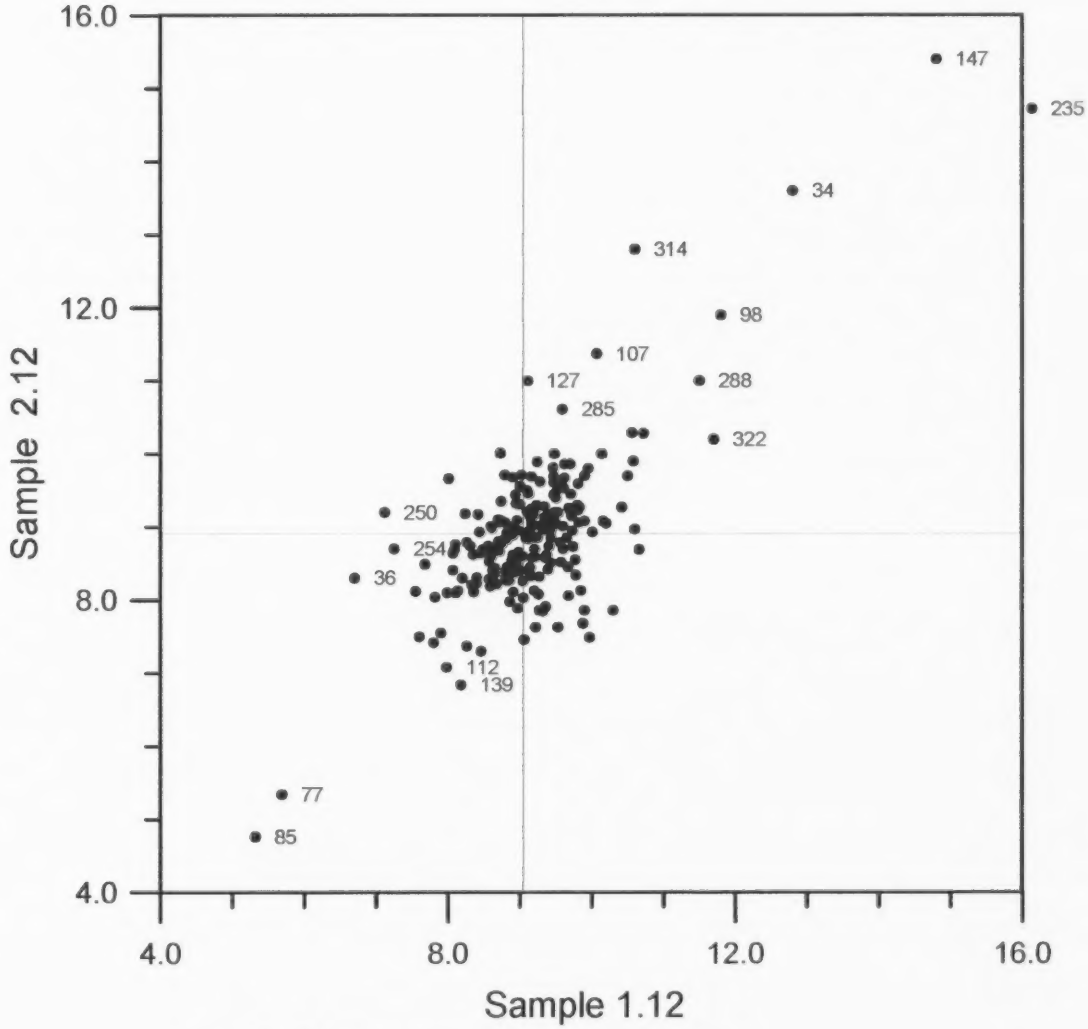
Test 24: Percent Passing the 150 um Sieve

	Mat 1	Mat 2
Mean	12.346	11.951
Median	12.400	11.950
Std Dev	0.800	0.822

n = 198

Lab Eliminated: 21; 34; 36; 77; 85; 98; 107; 126; 139; 147; 179; 186; 235; 250; 254; 276; 285; 288; 322

2012 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



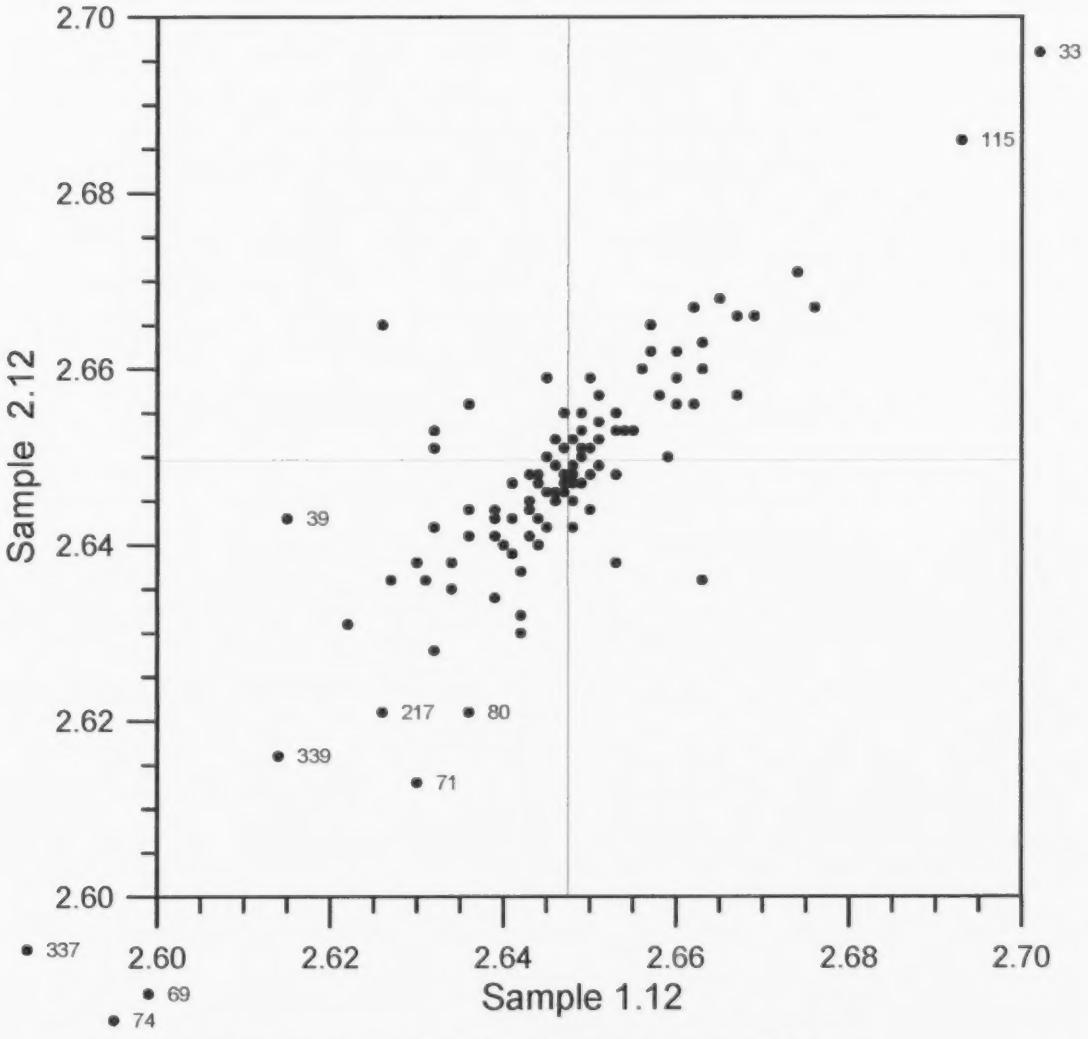
Test 25: Percent Passing the 75 um Sieve

	Mat 1	Mat 2
Mean	9.122	8.823
Median	9.135	8.795
Std Dev	0.619	0.604

n = 200

Labs Eliminated: 34; 36; 77; 85; 98; 107; 112; 127; 139; 147; 235; 250; 254; 285; 288; 314; 322

2012 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



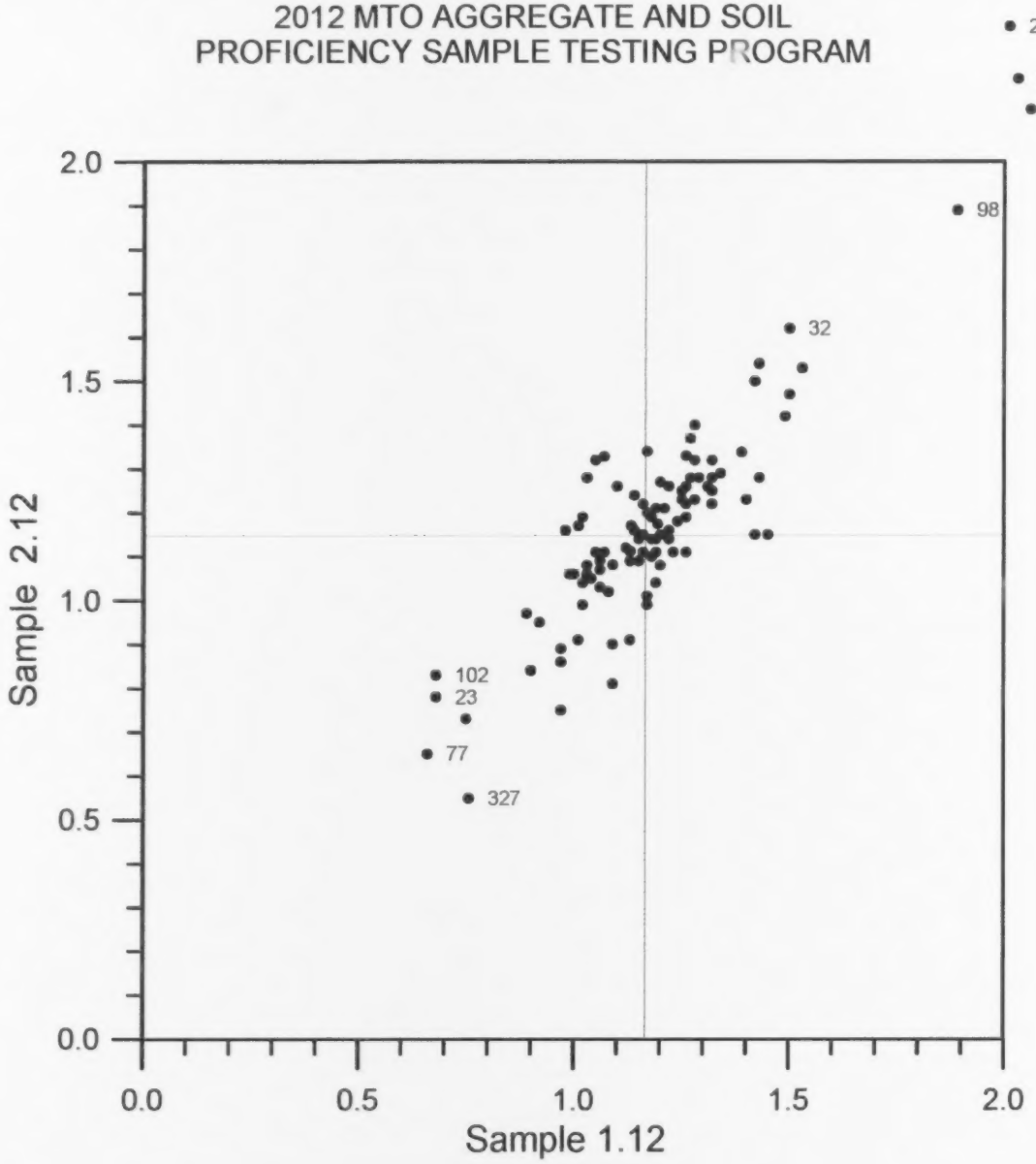
Test 27: Relative Density of Fine Aggregate (O. D)

	Mat 1	Mat 2
Mean	2.647	2.649
Median	2.649	2.650
Std Dev	0.011	0.009

n = 95

Labs Eliminated: 33; 39; 69; 71; 74; 80; 115; 217; 337; 339

2012 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



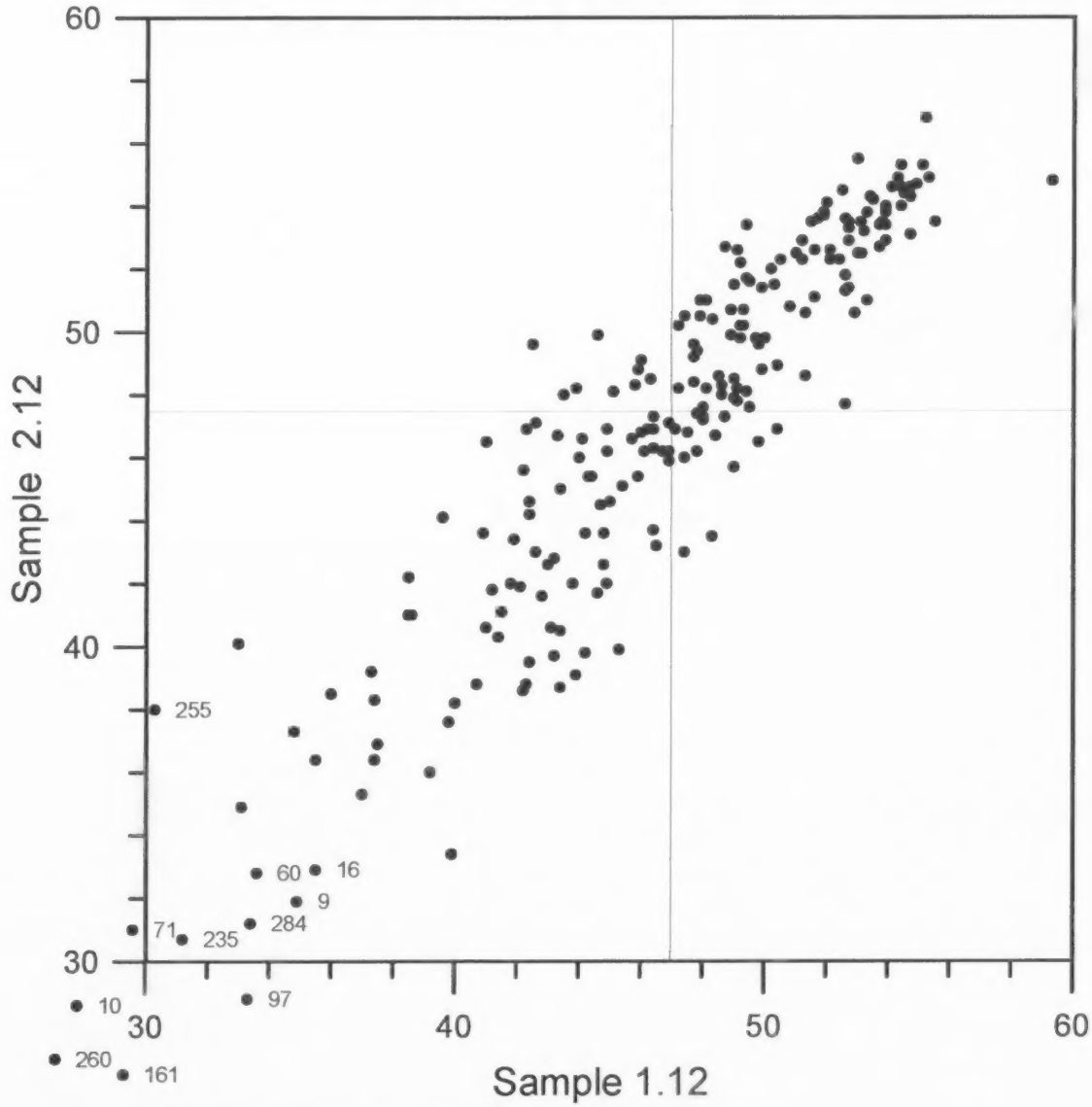
Test 28: Absorption of Fine Aggregate

	Mat 1	Mat 2
Mean	1.171	1.148
Median	1.140	1.135
Std Dev	0.155	0.164

n = 96

Labs Eliminated: 23; 32; 77; 98; 102; 257; 327; 337; 339;

2012 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



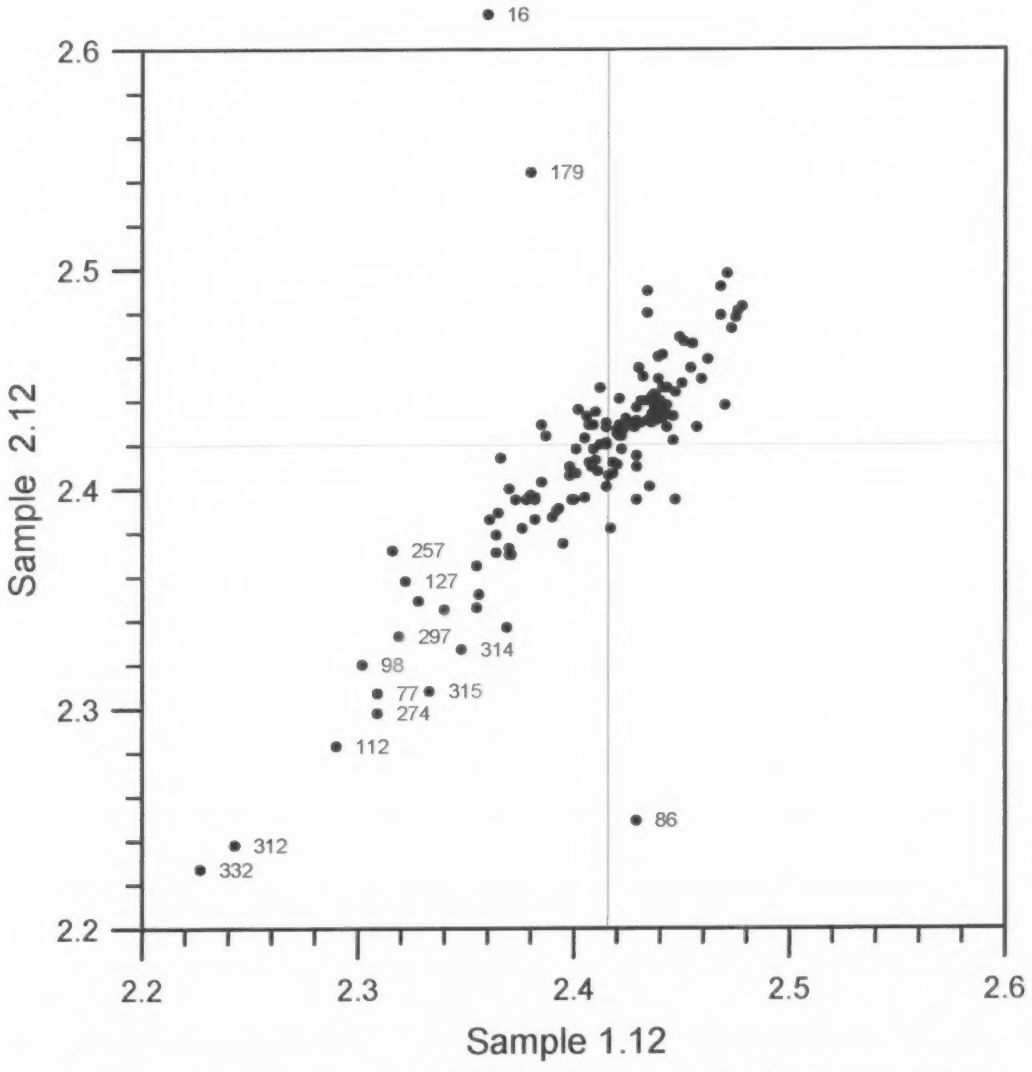
Test 30: Percent Asphalt Coated Particles

	Mat 1	Mat 2
Mean	47.132	47.634
Median	46.150	45.100
Std Dev	5.369	5.247

n = 205

Lab Eliminated: 9; 10; 16; 60; 71; 97; 161; 235; 255; 260; 284

2012 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



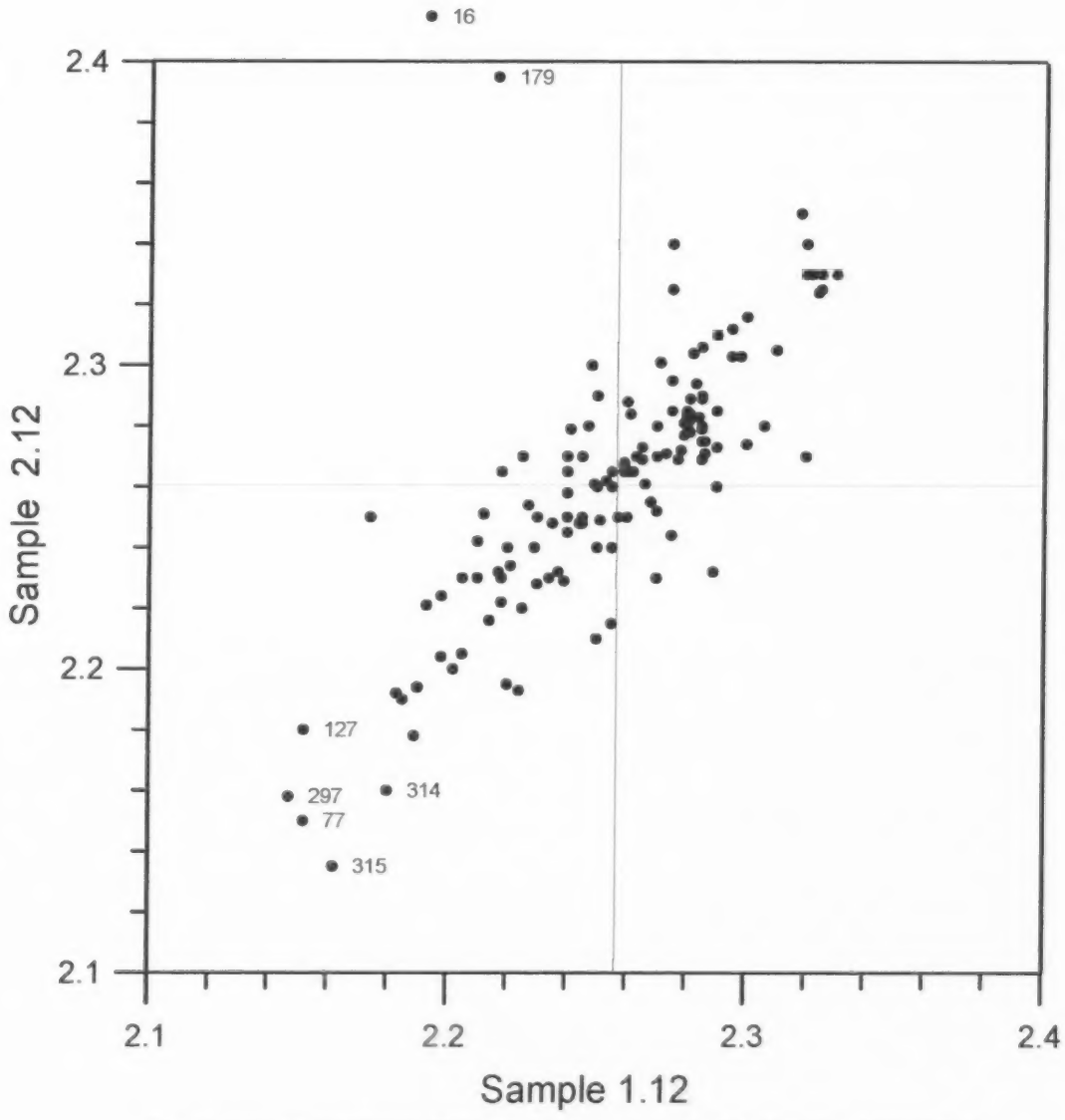
Test 31: Maximum Wet Density g/cm3 (Moisture-Density)

	Mat 1	Mat 2
Mean	2.416	2.421
Median	2.403	2.418
Std Dev	0.032	0.032

n = 133

Labs Eliminated: 16; 77; 86; 98; 112; 127; 179; 257; 274; 297; 312; 314; 315; 332

2012 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



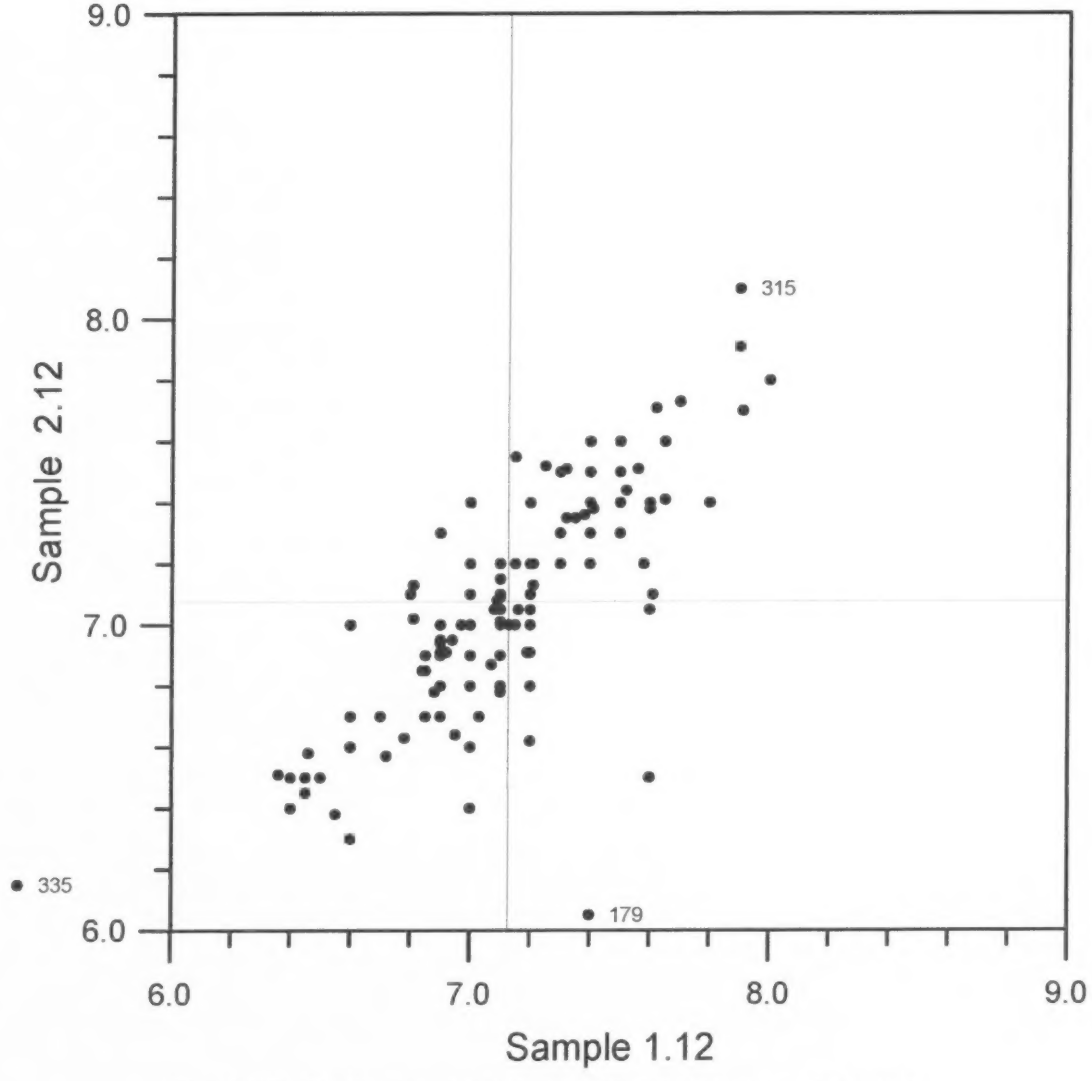
Test 32: Maximum Dry Density g/cm3 (Moisture-Density)

	Mat 1	Mat 2
Mean	2.257	2.264
Median	2.252	2.264
Std Dev	0.035	0.034

n = 140

Labs Eliminated: 16; 77; 127; 179; 297; 314; 315

2012 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



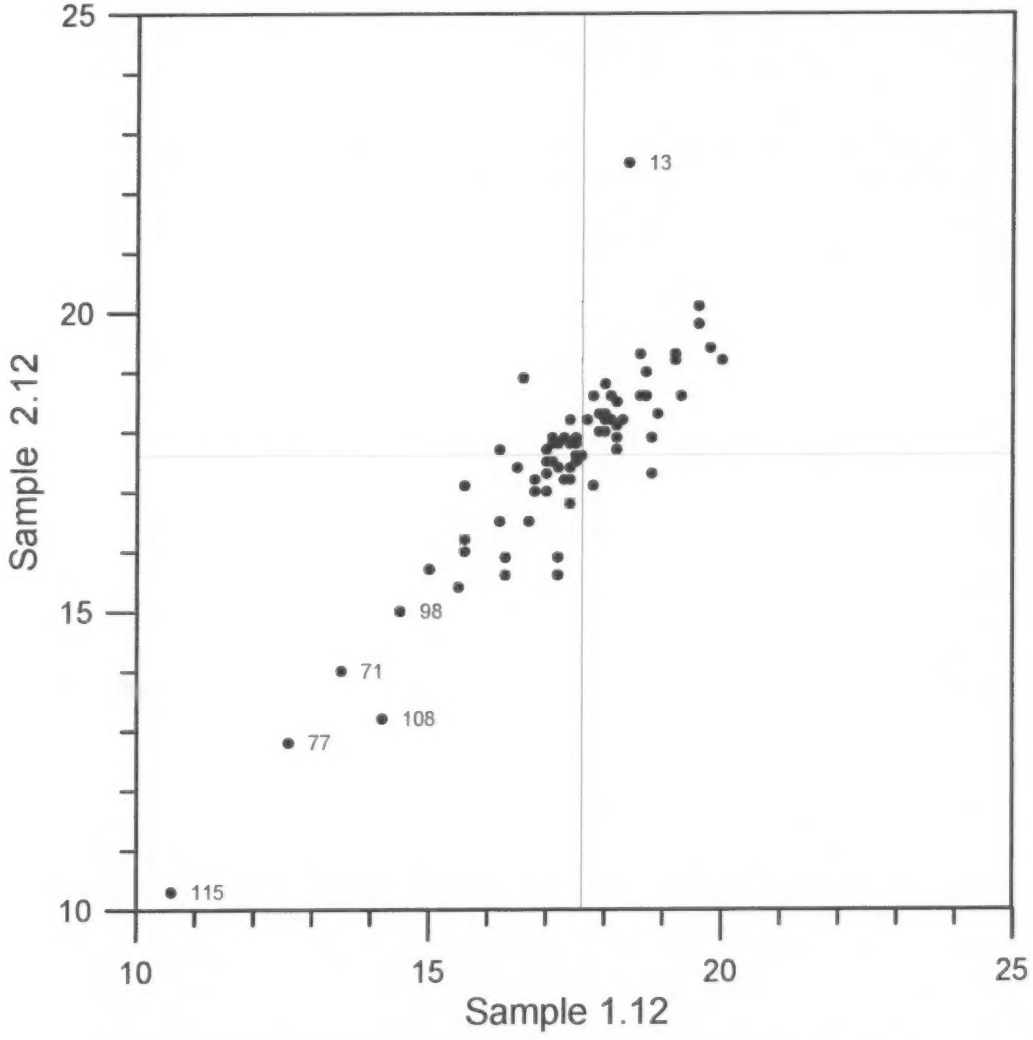
Test 33: Optimum Moisture, % (Moisture - Density)

	Mat 1	Mat 2
Mean	7.126	7.066
Median	7.180	7.105
Std Dev	0.329	0.325

n = 144

Labs Eliminated: 179; 315; 335

2012 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



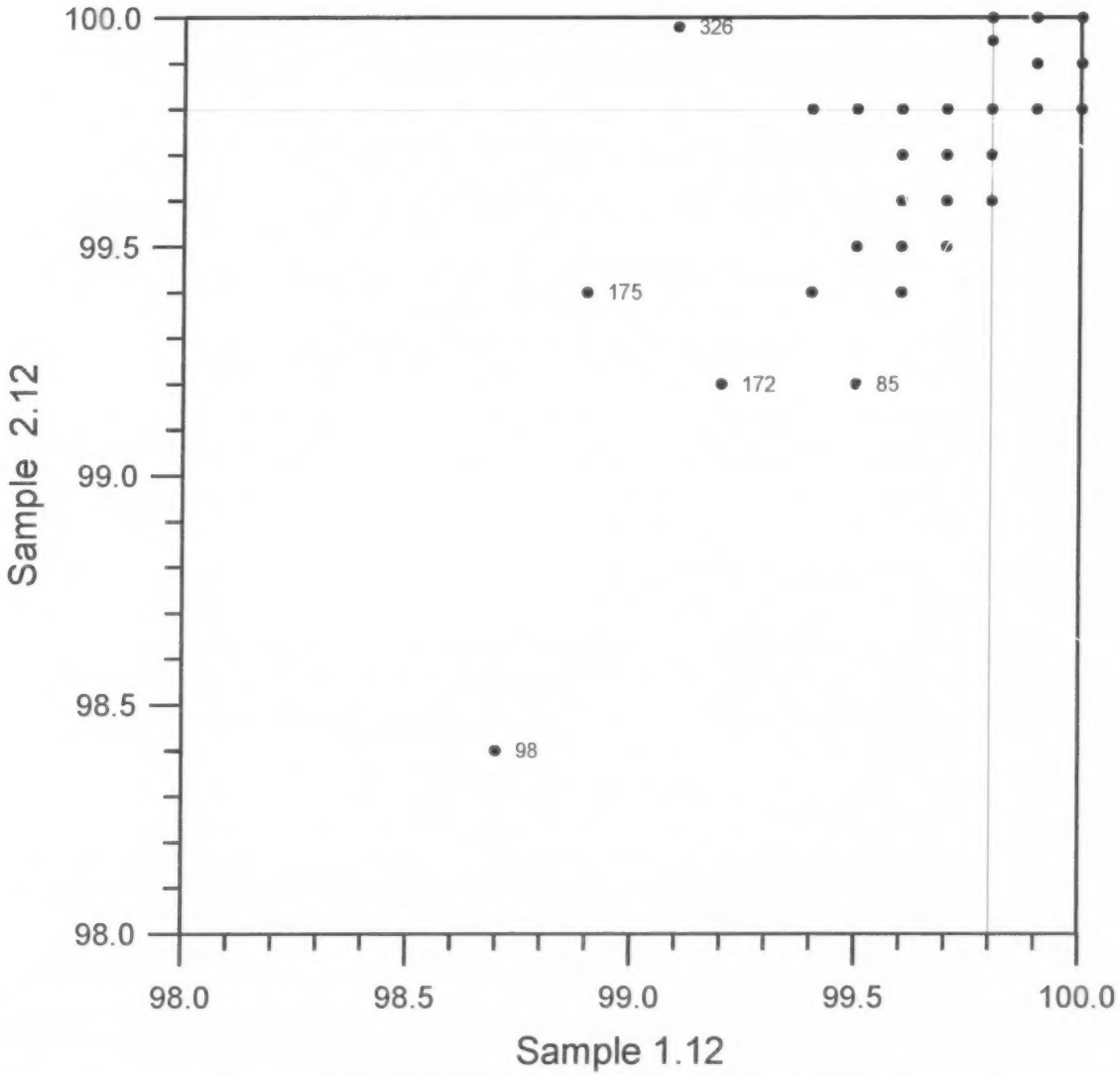
Test 34: Micro-Deval Abrasion Loss (FA), %

	Mat 1	Mat 2
Mean	17.628	17.738
Median	17.500	17.750
Std Dev	1.063	1.074

n = 71

Lab eliminated: 13; 71; 77; 98; 108; 115

2012 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



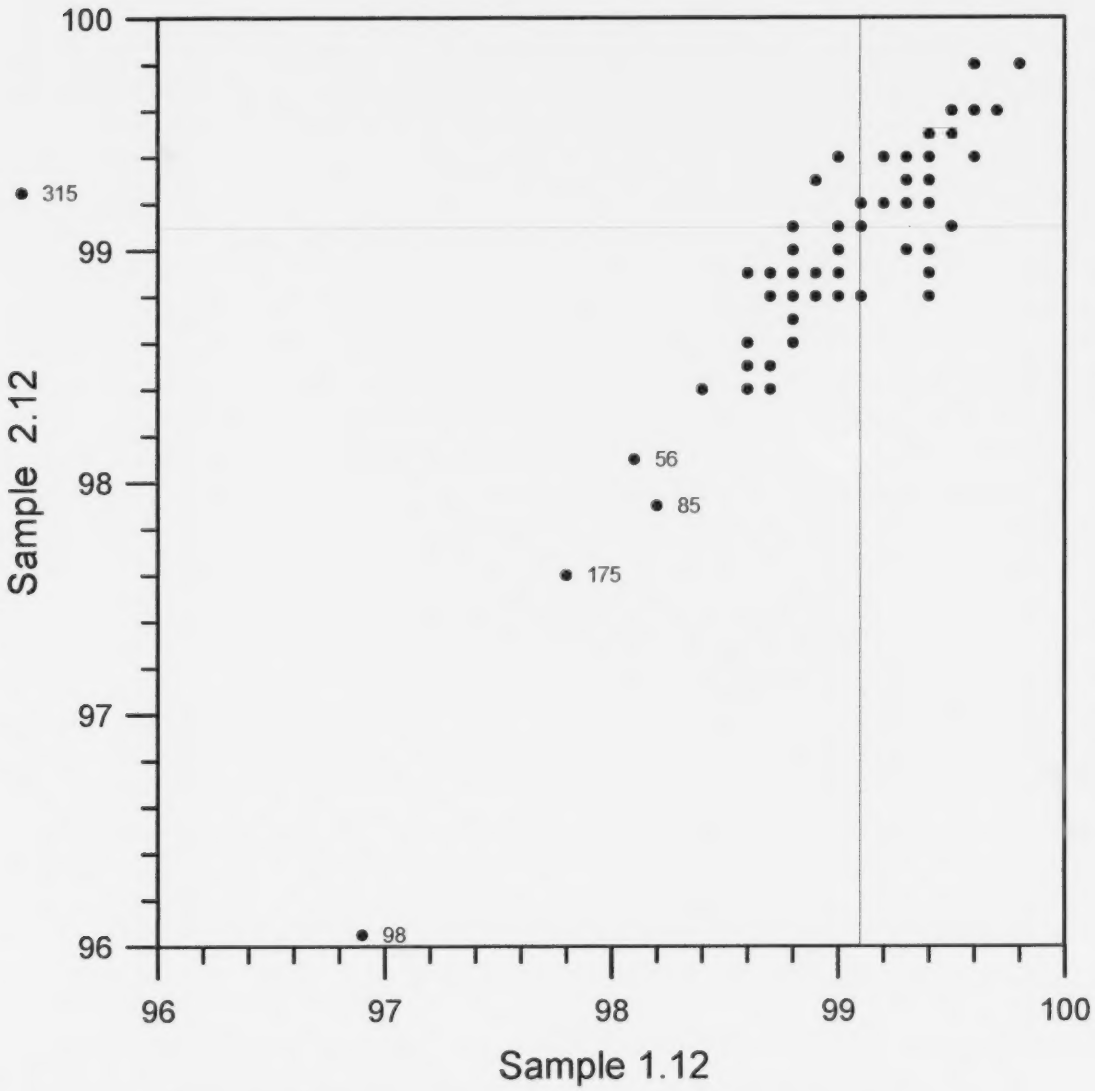
Test 41: Percent Passing the 425 μm Sieve (Soil)

	Mat 1	Mat 2
Mean	99.793	99.784
Median	99.700	99.700
Std Dev	0.175	0.185

n = 71

Labs eliminated: 85; 98; 172; 175; 326

2012 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



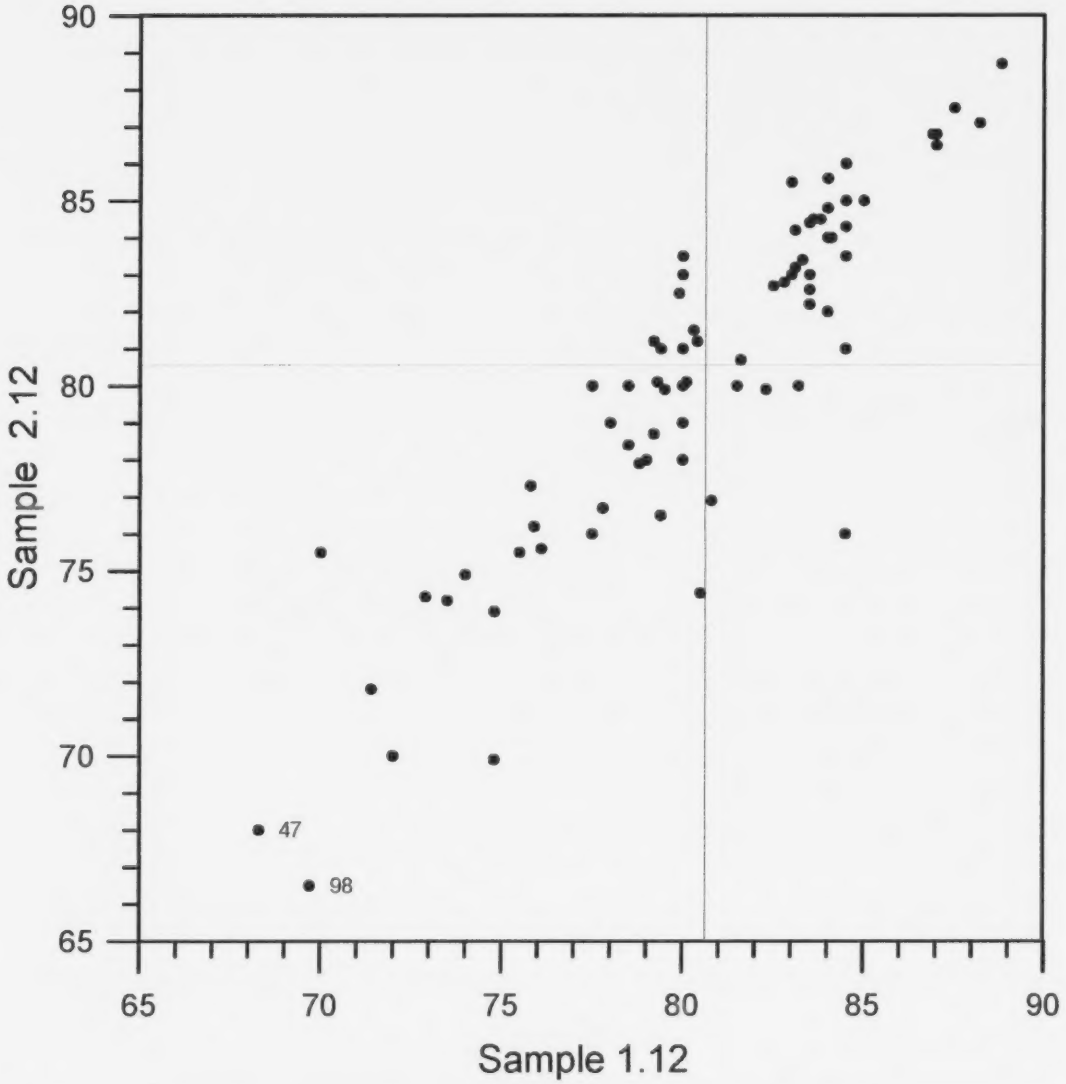
Test 42: Percent Passing the 75 μm Sieve (Soil)

	Mat 1	Mat 2
Mean	99.103	99.100
Median	99.100	99.100
Std Dev	0.343	0.337

n = 71

Labs eliminated: 56; 85; 98; 175; 315

2012 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



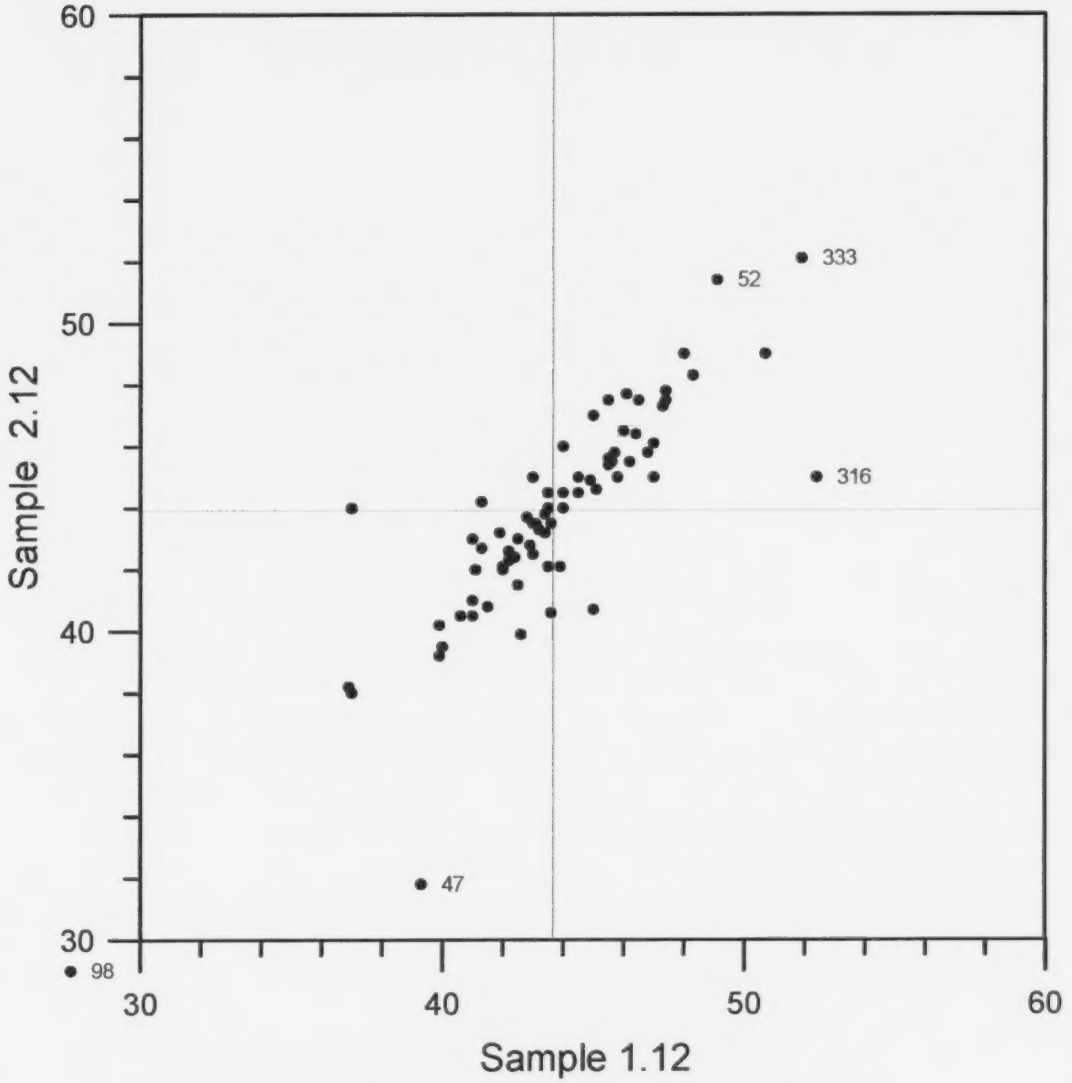
Test 43: Percent Passing the 20 μm Sieve (Soil)

	Mat 1	Mat 2
Mean	80.643	80.639
Median	79.400	79.300
Std Dev	4.241	4.229

n = 74

Labs eliminated: 47; 98

2012 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



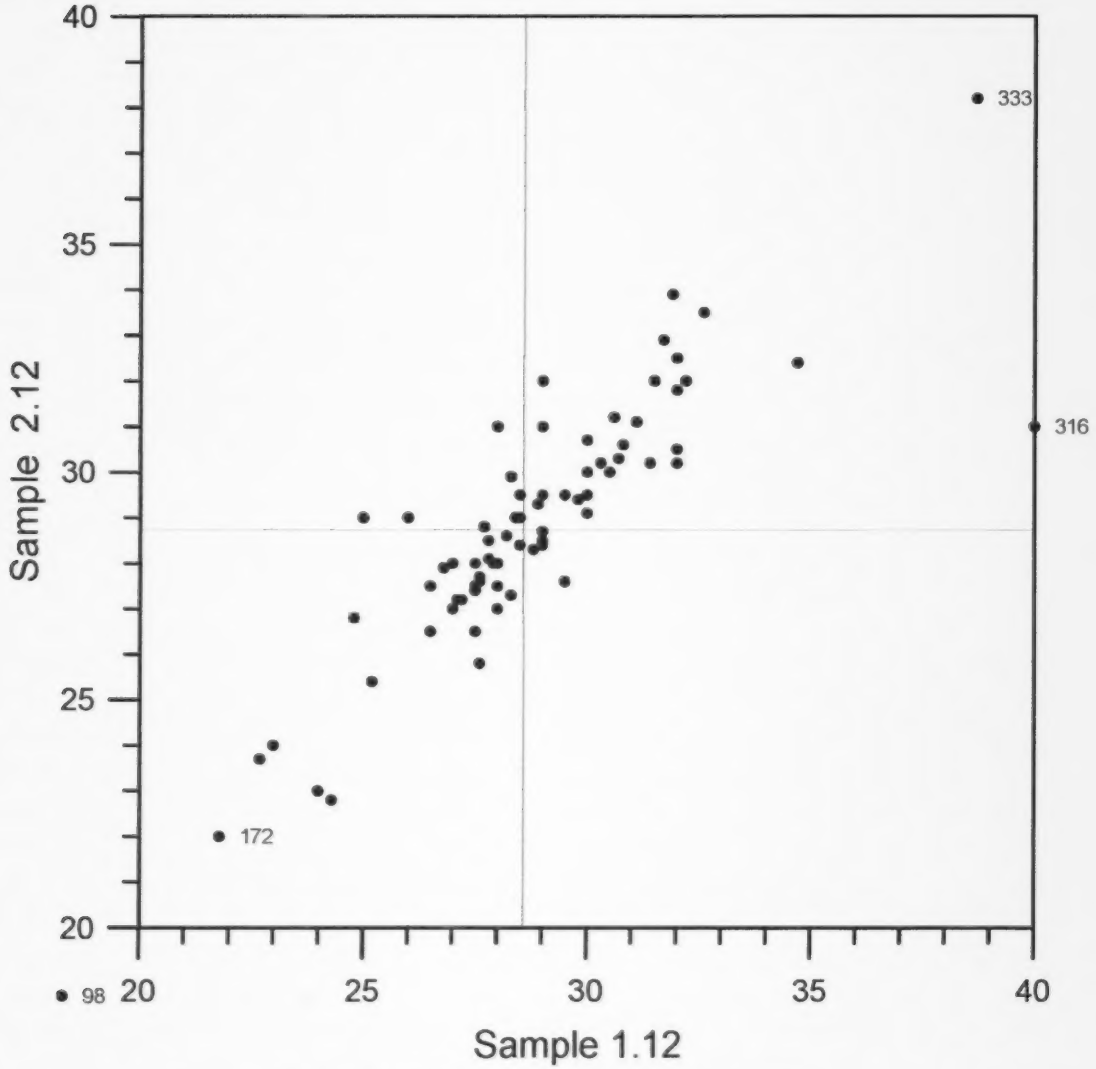
Test 44: Percent Passing the 5 μm Sieve (Soil)

	Mat 1	Mat 2
Mean	43.736	43.899
Median	43.800	43.500
Std Dev	2.741	2.552

n = 71

Labs eliminated: 47; 52; 98; 316; 333

2012 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



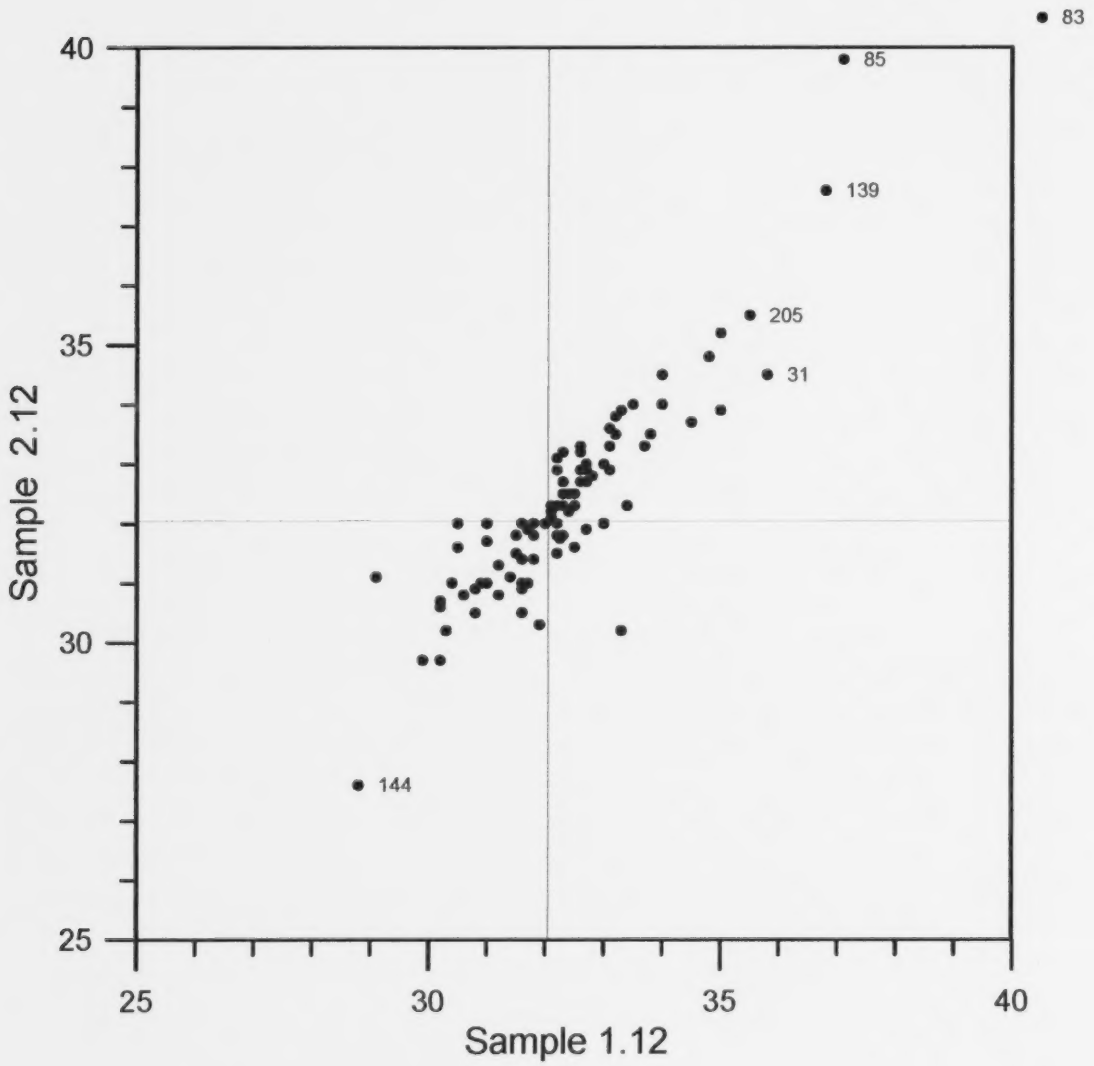
Test 45: Percent Passing the 2 μm Sieve (Soil)

	Mat 1	Mat 2
Mean	28.569	28.833
Median	28.700	28.350
Std Dev	2.330	2.318

n = 72

LabsEliminated: 98; 172; 316; 333

2012 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



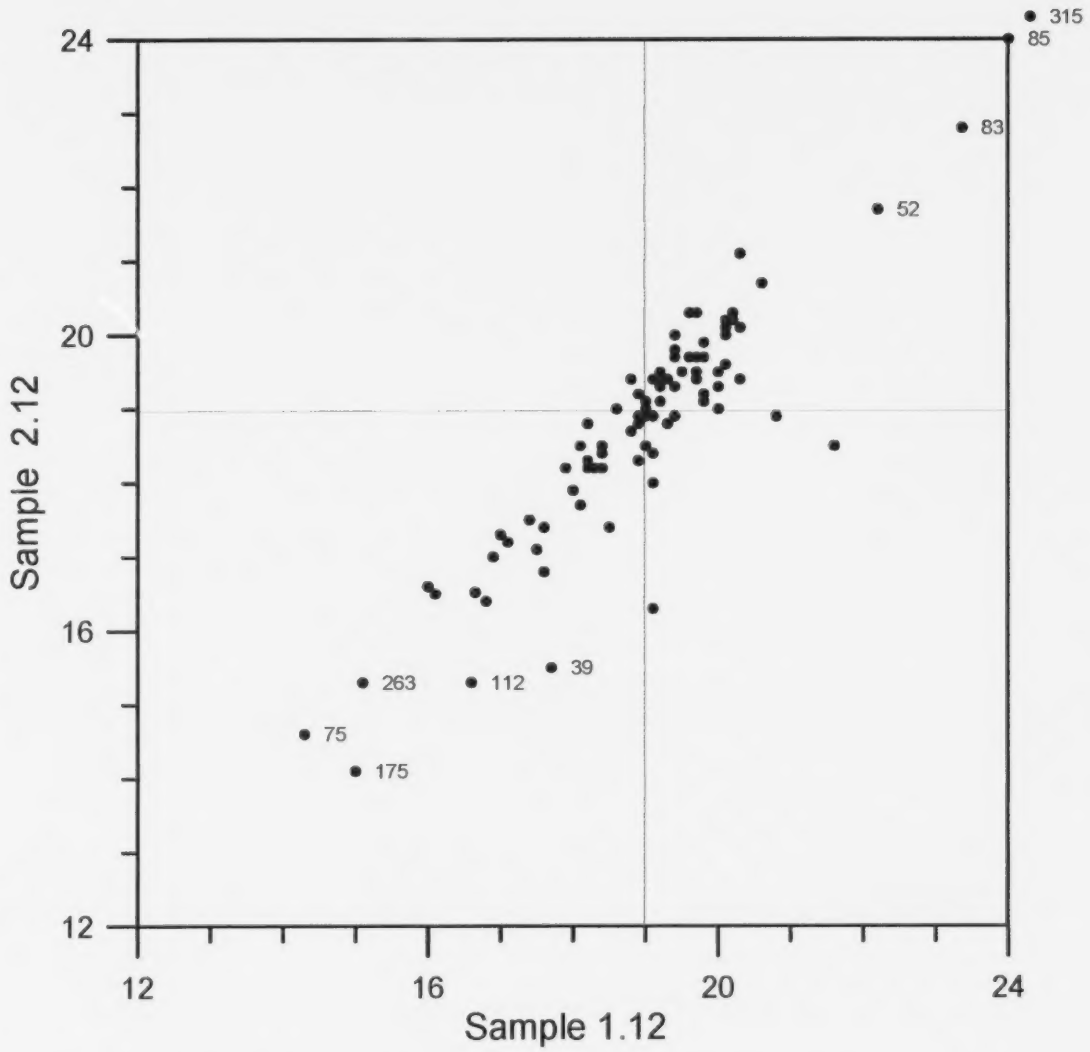
Test 46: Liquid Limit, %

	Mat 1	Mat 2
Mean	32.167	32.158
Median	32.050	32.450
Std Dev	1.168	1.156

n = 89

Lab eliminated: 31; 83; 85; 139; 144; 205

2012 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



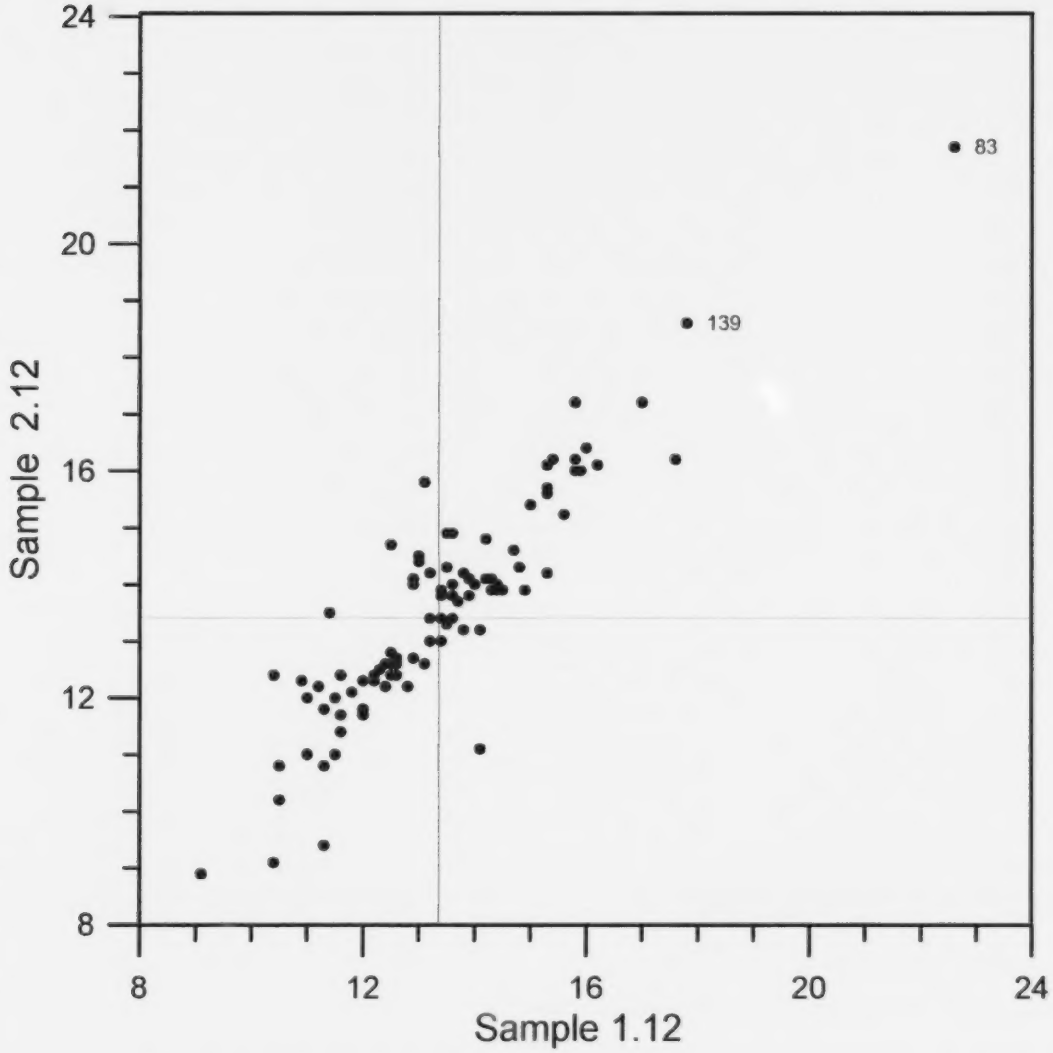
Test 47: Plastic Limit, %

	Mat 1	Mat 2
Mean	18.951	18.877
Median	18.800	18.700
Std Dev	1.102	1.112

n = 86

Labs eliminated: 39; 52; 75; 83; 85; 112; 175; 263; 315

2012 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



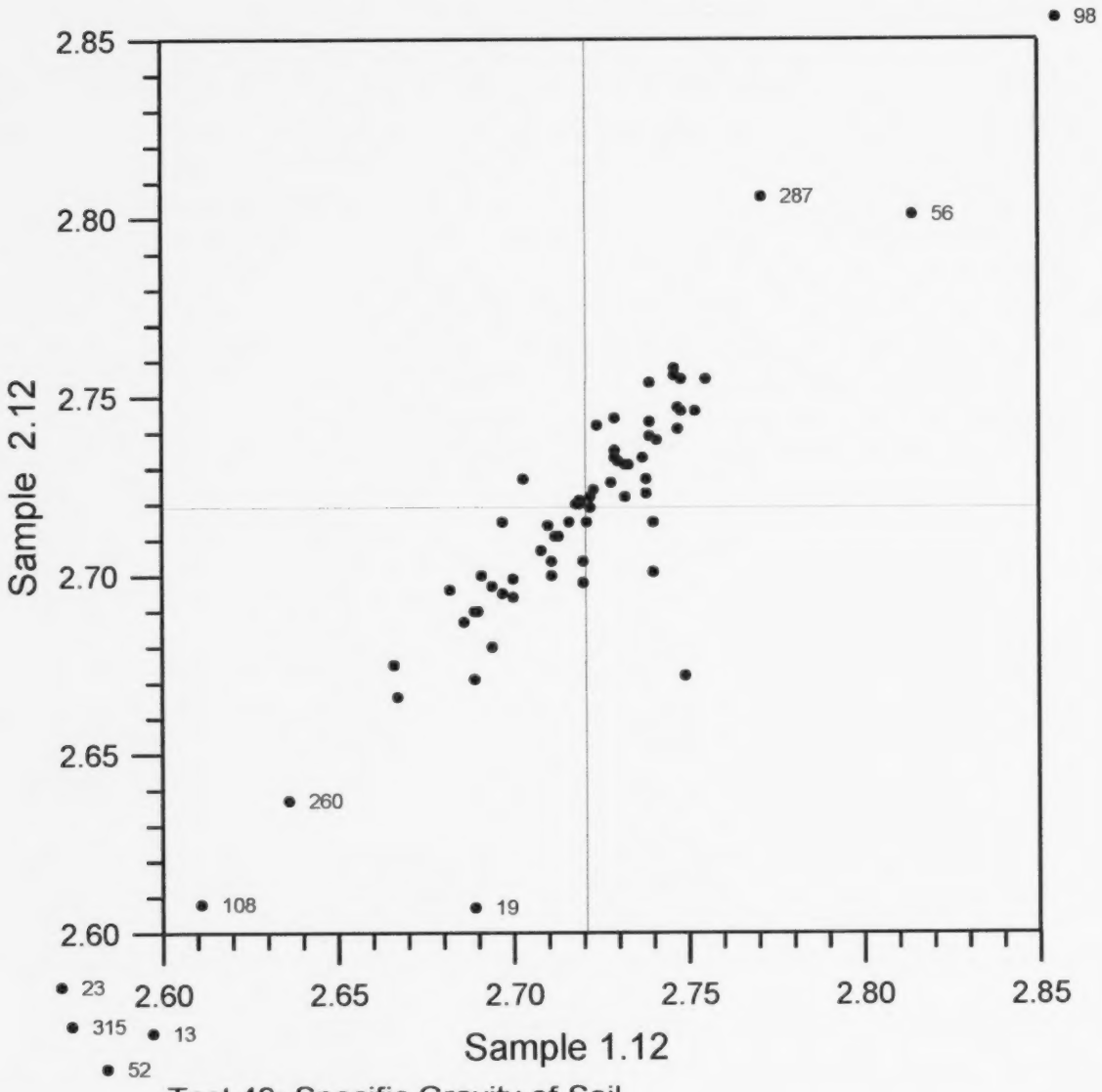
Test 48: Plasticity Index, %

	Mat 1	Mat 2
Mean	13.288	13.415
Median	13.350	13.050
Std Dev	1.700	1.721

n = 93

Lab eliminated: 83; 139

2012 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



Test 49: Specific Gravity of Soil

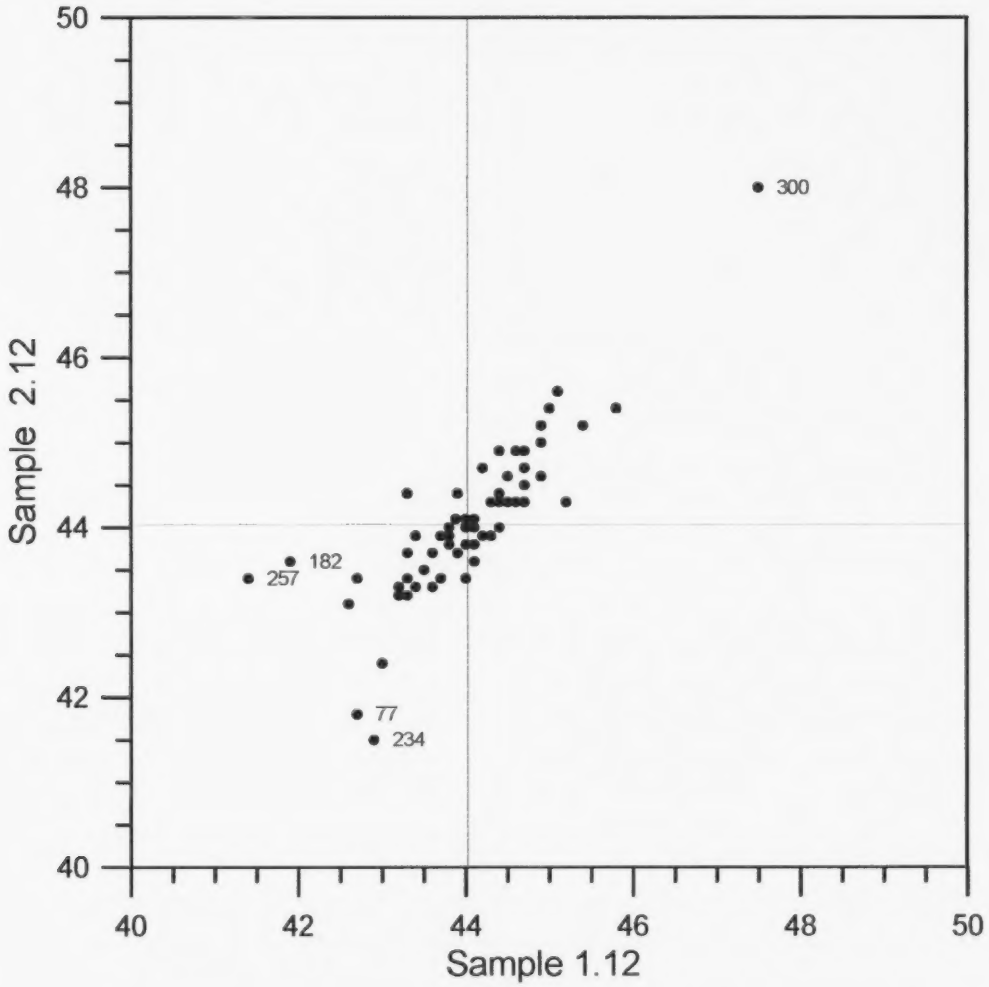
	Mat 1	Mat 2
Mean	2.721	2.718
Median	2.711	2.712
Std Dev	0.023	0.023

n = 60

Labs Eliminated: 13; 19; 23; 52; 56; 98; 108; 260; 287; 315

Appendix D2: Scatter Diagrams

2012 MTO SUPERPAVE
CONSENSUS PROPERTY TESTING PROGRAM



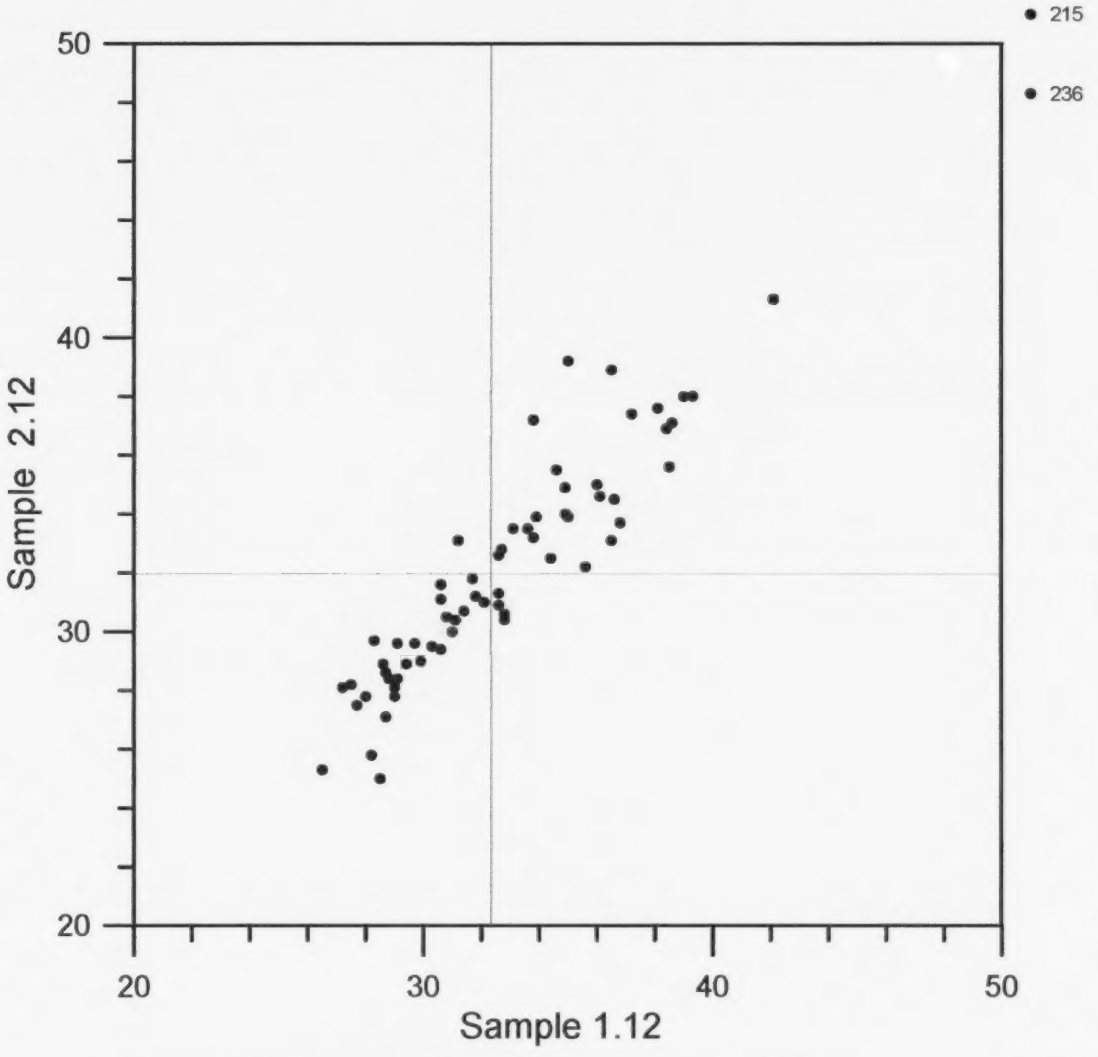
Test 95: Uncompacted Void Content of Fine Aggregate

	Mat 1	Mat 2
Mean	44.044	44.057
Median	44.200	44.000
Std Dev	0.658	0.628

n = 66

Labs eliminated: 77; 182; 234; 257; 300

2012 MTO SUPERPAVE
CONSENSUS PROPERTY TESTING PROGRAM



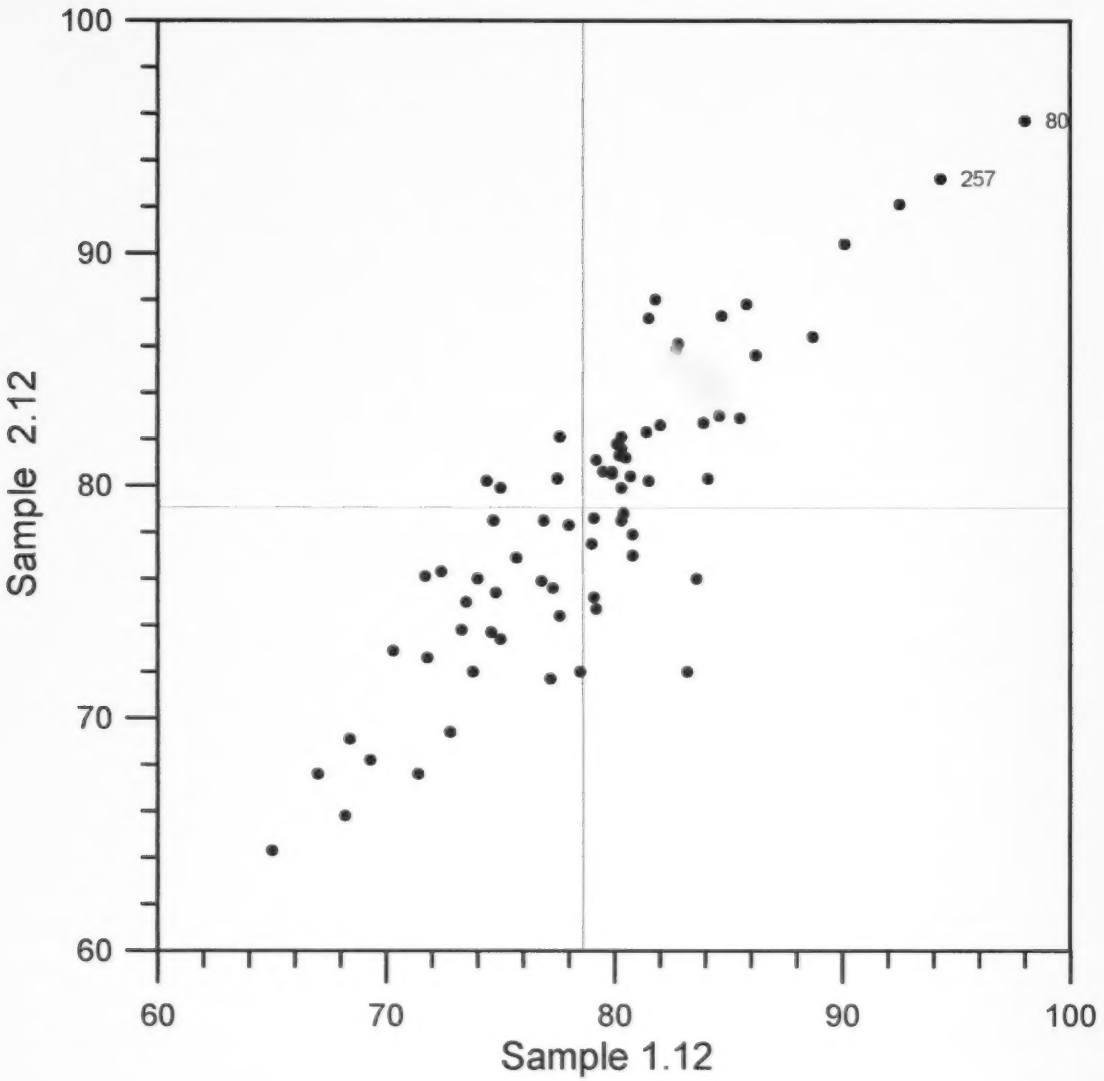
Test 96: Sand Equivalent Value of Fine Aggregate

	Mat 1	Mat 2
Mean	32.519	31.959
Median	34.300	33.150
Std Dev	3.620	3.669

n = 65

Labs eliminated: 215; 236

2012 MTO SUPERPAVE
CONSENSUS PROPERTY TESTING PROGRAM



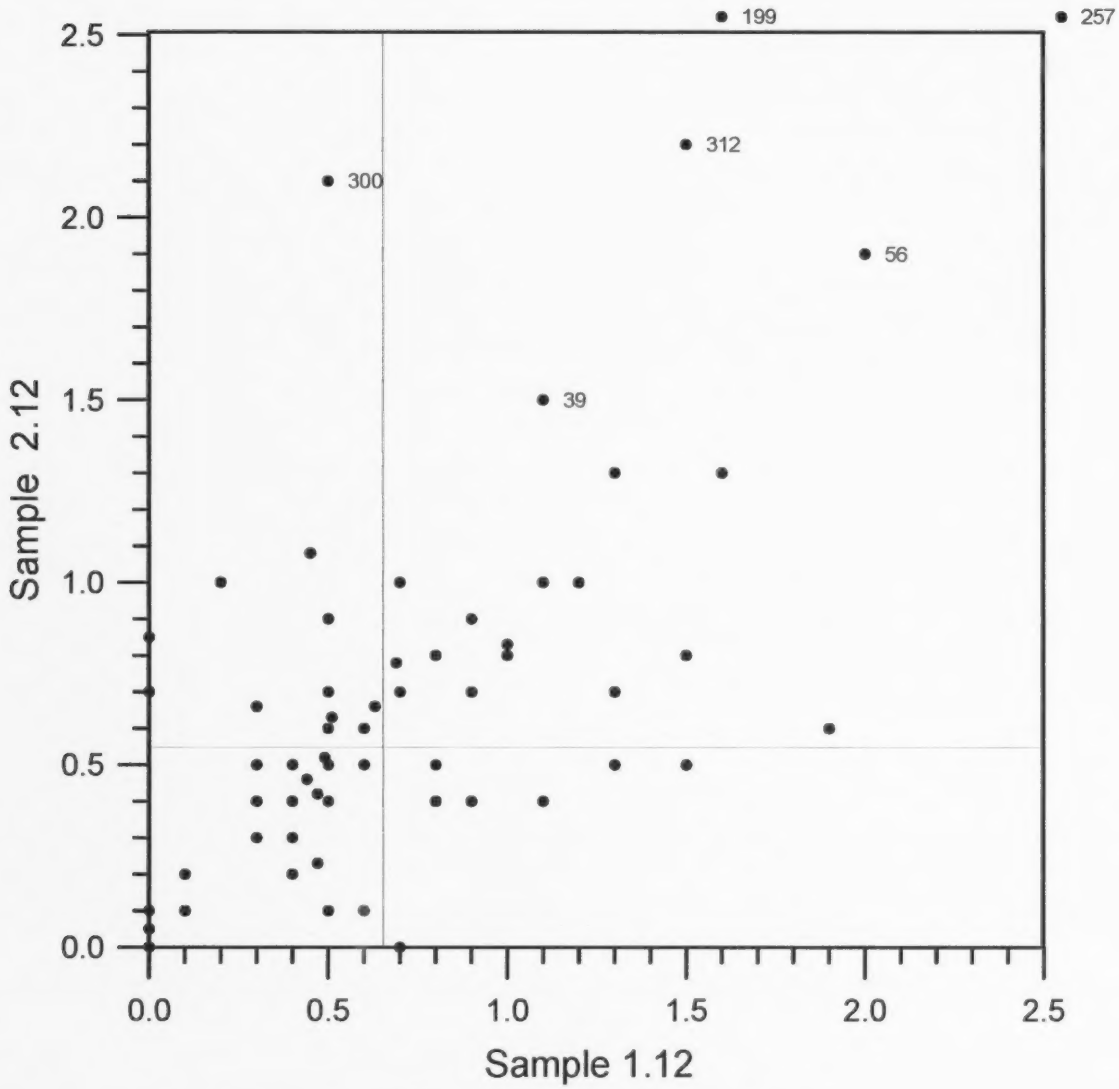
Test 97: Percent Fractured Particles

	Mat 1	Mat 2
Mean	78.499	78.818
Median	78.750	78.200
Std Dev	5.425	6.399

n = 70

Labs Eliminated: 80; 257

2012 MTO SUPERPAVE
CONSENSUS PROPERTY TESTING PROGRAM



Test 99: Percent Flat and Elongated Particles

	Mat 1	Mat 2
Mean	0.664	0.551
Median	0.950	0.650
Std Dev	0.458	0.316

n = 66

Lab Eliminated: 39; 56; 199; 257; 300; 312

Appendix E1: Production Laboratory Ratings

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
2	8	28.6	10	10	8	92
4	9	25.1	10	10	10	92
8	10	28.6	10	10	10	98
9	9	25.6	10	2	10	81
11	9	27.5	10	9	5	86
12	8	30.0	10	10	9	96
13	6	26.7	10	8	7	82
15	10	30.0	10	10	10	100
16	6	26.2	5	2	10	70
17	7	26.2	2	8	7	72
18	8	30.0	10	10	10	97
19	10	28.9	6	10	10	93
20	10	29.7	10	10	6	94
21	10	16.4	7	10	10	76
22	10	26.7	9	8	9	90
23	0	29.2	10	10	10	85
25	10	28.1	9	10	10	96
26	10	27.3	9	7	6	85
27	8	23.7	6	10	10	82
28	10	27.5	10	8	10	94
29	10	27.5	10	10	10	96
30	9	26.5	10	8	9	89
31	10	28.6	10	9	10	97
32	6	27.0	10	10	10	90
33	10	26.5	10	10	10	95
34	9	1.4	0	8	0	26
35	10	30.0	10	10	10	100
36	0	20.7	10	5	10	65
37	9	22.1	10	10	6	82
38	9	30.0	10	9	10	97
39	10	30.0	3	10	10	90
41	10	29.7	10	10	10	100
42	10	30.0	0	3	6	70
43	8	28.6	3	8	5	75
44	10	26.5	10	7	7	86

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
45	10	27.8	10	6	10	91
46	5	27.0	9	8	7	80
47	10	27.3	10	9	8	92
52	6	28.6	9	7	9	85
54	10	24.8	10	9	6	85
56	7	28.6	9	10	9	91
58	10	28.9	10	7	10	94
59	10	29.7	9	10	10	98
60	10	26.7	8	1	0	65
61	10	27.3	9	10	10	95
62	9	24.3	10	8	10	88
63	8	28.4	0	10	10	81
64	10	21.3	10	6	8	79
65	10	24.0	10	9	10	90
68	10	30.0	10	10	10	100
69	6	28.1	10	10	10	92
70	5	27.3	10	10	7	85
71	10	28.6	10	0	10	84
72	10	21.3	10	10	10	88
73	2	12.5	10	7	8	56
74	10	28.4	10	9	10	96
75	10	27.3	10	10	7	92
76	10	30.0	5	10	10	93
77	0	16.9	10	6	10	61
78	7	23.7	8	4	10	75
79	10	27.3	10	6	10	90
80	9	28.4	1	8	10	81
81	6	29.2	8	10	10	90
83	9	29.2	8	8	10	92
85	0	17.7	10	8	2	54
86	7	29.2	10	10	10	95
89	10	30.0	8	8	8	91
90	9	24.5	9	9	0	74
93	10	27.0	10	8	10	93
94	10	29.2	10	10	3	89
97	10	29.7	6	1	10	81
98	2	22.1	10	10	10	77
99	10	23.5	10	5	2	72
100	5	28.9	9	10	7	86

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
101	9	24.3	7	10	8	**83**
102	10	19.1	10	8	10	**82**
103	7	26.7	10	7	10	**87**
107	10	23.5	8	8	10	**85**
108	4	28.9	10	10	7	**86**
110	10	30.0	10	10	10	**100**
112	10	21.0	5	8	8	**74**
113	8	25.1	8	8	10	**84**
115	10	28.6	10	10	10	**98**
116	8	22.6	6	9	10	**79**
117	3	27.0	10	10	10	**86**
118	10	25.4	7	8	8	**83**
119	4	22.9	6	9	6	**68**
120	9	27.0	10	8	10	**91**
122	10	28.6	10	10	10	**98**
124	10	27.5	10	10	6	**91**
126	0	16.1	8	9	10	**62**
127	8	20.5	10	10	9	**82**
128	9	27.8	10	9	8	**91**
129	10	29.5	10	10	8	**96**
138	10	27.3	10	10	10	**96**
139	5	19.9	10	10	8	**76**
141	10	28.9	10	10	10	**98**
143	9	30.0	10	8	10	**96**
144	10	22.4	10	9	10	**88**
146	10	22.4	6	10	10	**83**
147	0	13.6	2	10	10	**51**
154	10	28.1	10	10	10	**97**
157	8	28.4	10	10	8	**92**
158	10	28.6	10	8	10	**95**
160	9	26.2	10	7	9	**87**
161	8	24.8	10	0	9	**74**
163	10	24.5	10	8	9	**88**
164	10	29.7	10	10	10	**100**
167	10	26.2	10	10	8	**92**
169	8	30.0	8	10	10	**94**
172	10	22.1	10	10	10	**89**
175	10	25.9	10	8	10	**91**
176	8	26.7	8	9	10	**88**

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
177	10	28.4	9	10	10	96
178	10	26.7	7	10	9	90
179	8	6.3	4	10	10	55
180	10	27.5	10	10	8	94
181	9	27.5	10	10	6	89
182	8	29.5	8	10	9	92
184	8	28.1	9	10	9	92
186	10	21.0	8	10	8	81
187	10	28.6	10	10	10	98
188	10	29.5	10	10	10	99
191	6	21.3	10	10	9	80
193	9	24.3	10	8	10	88
194	7	28.6	10	10	9	92
196	9	23.7	0	9	6	68
198	10	22.6	9	10	10	88
199	10	27.8	10	10	10	97
200	10	28.1	10	10	10	97
205	9	25.9	9	5	9	83
208	0	24.0	10	10	7	73
210	10	26.2	10	10	9	93
214	4	21.8	10	9	0	64
215	8	27.5	8	8	10	88
216	10	30.0	10	10	10	100
217	10	27.0	10	10	7	91
218	5	20.2	9	8	7	70
219	10	23.7	10	9	10	90
223	10	25.6	10	10	6	88
232	9	21.0	0	8	6	63
234	10	25.4	10	10	10	93
235	3	10.4	0	0	9	32
236	10	24.8	4	10	10	84
245	5	23.7	7	7	10	75
248	9	28.9	10	10	10	97
249	10	28.1	10	10	5	90
250	7	16.4	10	8	9	72
251	10	29.5	10	8	5	89
252	6	25.9	7	10	10	84
254	10	22.6	9	9	10	87
255	10	29.2	10	3	9	87

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
257	10	23.5	5	10	10	84
258	9	29.7	10	10	4	90
260	10	26.5	9	0	4	71
262	9	26.7	9	5	0	71
263	10	28.6	10	10	10	98
264	10	29.7	10	10	8	97
267	10	30.0	8	9	9	94
268	10	29.2	9	9	10	96
269	8	29.7	3	8	10	84
271	10	29.2	9	9	10	96
272	10	28.6	4	10	10	89
27[illegible]	10	28.6	10	8	10	95
275	10	27.3	10	10	10	96
276	8	22.6	10	5	9	78
277	0	24.3	6	10	9	70
278	4	27.3	9	10	10	86
279	9	24.8	10	8	9	87
280	9	20.5	10	10	10	85
282	10	29.2	10	9	7	93
284	9	30.0	5	1	9	77
285	10	21.0	10	8	10	84
287	3	28.1	10	8	10	84
288	5	16.6	10	10	10	74
290	10	29.5	6	5	10	86
291	10	22.4	9	5	10	81
293	8	28.1	10	10	9	93
294	10	24.8	9	9	9	88
295	10	29.5	10	10	10	99
296	10	29.5	10	10	10	99
297	9	26.5	10	10	10	94
299	10	28.4	8	10	10	95
300	10	28.6	10	10	10	98
301	9	27.5	9	10	6	88
302	10	24.0	9	10	4	81
303	9	26.2	10	10	10	93
305	10	27.8	0	10	0	68
308	10	30.0	10	10	9	99
309	4	25.4	10	10	1	72
310	7	25.1	5	9	7	76

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
311	10	27.3	10	9	10	**95**
312	8	24.8	5	10	9	**81**
313	10	24.5	0	9	10	**76**
314	8	18.0	9	8	9	**74**
315	2	28.9	0	6	10	**67**
316	10	30.0	10	10	10	**100**
318	9	27.8	10	10	10	**95**
320	10	28.6	6	10	7	**88**
321	10	25.9	10	10	10	**94**
322	10	18.8	2	9	10	**71**
323	8	27.5	10	10	9	**92**
324	8	30.0	8	10	10	**94**
326	10	25.9	10	10	9	**93**
327	7	28.6	7	10	9	**88**
328	10	30.0	8	8	10	**94**
329	0	27.0	10	9	10	**80**
331	9	23.5	10	8	8	**84**
332	8	28.9	10	8	10	**93**
333	10	24.5	7	9	10	**86**
335	8	23.2	5	10	10	**80**
337	9	25.4	5	10	5	**78**
339	10	29.7	10	10	9	**98**
340	10	24.5	10	10	10	**92**

Appendix E2: Full Service Aggregate Laboratory Ratings

FULL SERVICE AGGREGATE LABORATORY RATINGS 2012

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-603 LAA	LS-604 BRD/ABS (CA)	LS-606 $MgSO_4$ (CA)	LS-607 % Crush	LS-621 % Asphalt	LS-608 % Flat & Elongated	LS-618 MDA (CA)	LS-614 F/T	LS-605 BRD/ABS (FA)	LS-623 One-Point Proctor	LS-619 MDA (FA)	Rating
8	10	28.6		9.5	10	10	10	10	10	10	10.0	10.0	8	**97**
12	8	30.0		10.0	9	10	10	9	9	7	10.0	10.0	10	**94**
13	6	26.7		10.0	6	10	8	7	9	8	9.5	10.0	0	**79**
15	10	30.0		8.0	10	10	10	10	8	8	10.0	10.0	10	**96**
18	8	30.0		10.0	9	10	10	10	9	8	10.0	9.0	9	**94**
19	10	28.9	8	10.0		6	10	10	10	10	9.5	10.0	10	**95**
22	10	26.7		9.5		9	8	9	10	7	10.0	10.0	10	**92**
27	8	23.7	9	5.5	10	6	10	10	10	10	9.0	10.0	9	**87**
28	10	27.5		8.5		10	8	10	8	8	8.5	10.0	6	**88**
31	10	28.6	10	8.5	8	10	9	10	9	10	10.0	10.0	10	**95**
35	10	30.0	10	9.5	10	10	10	10	10	9	10.0	6.0	10	**96**
37	9	22.1		10.0	9	10	10	6	10	10	10.0	10.0	10	**90**
38	9	30.0	9	10.0	10	10	9	10	7	10	10.0	10.0	10	**96**
39	10	30.0		7.0		3	10	10	7	9	7.5	9.7	9	**86**
47	10	27.3	6	10.0	7	10	9	8	10	9	9.5	10.0	10	**91**
56	7	28.6	10	10.0	10	9	10	9	10	0	9.5	9.0	10	**88**
59	10	29.7		9.5	10	9	10	10	10	10	9.5	10.0	10	**98**
61	10	27.3		10.0		9	10	10	10	10	9.5	9.0	5	**92**
69	6	28.1		10.0		10	10	10	10	3	4.5	10.0	9	**85**
75	10	27.3		8.5	10	10	10	7	10	10	9.0	10.0	9	**93**
76	10	30.0		10.0	10	5	10	10	10	10	10.0		10	**96**
78	7	23.7		8.5		8	4	10	10	7	9.0	10.0	10	**82**

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-603 LAA	LS-604 BRD/ABS (CA)	LS-606 $MgSO_4$ (CA)	LS-607 % Crush	LS-621 % Asphalt	LS-608 % Flat & Elongated	LS-618 MDA (CA)	LS-614 F/T	LS-605 BRD/ABS (FA)	LS-623 One-Point Proctor	LS-619 MDA (FA)	Rating
79	10	27.3		9.5		10	6	10	10	10	9.5	9.3	10	**94**
80	9	28.4	10	8.5	10	1	8	10	10	7	6.5	4.3	10	**82**
83	9	29.2		9.0	10	8	8	10	10	10	10.0	9.7	10	**95**
86	7	29.2		9.0		10	10	10	10	3	8.5	8.3	7	**86**
90	9	24.5		9.0	6	9	9	0	7		8.5		8	**75**
98	2	22.1		9.0	10	10	10	10	3	4	3.0	6.0	1	**64**
101	9	24.3	9	9.0	10	7	10	8	10	10	10.0	10.0	10	**91**
102	10	19.1		9.0		10	8	10	10	10	5.5	10.0	10	**86**
107	10	23.5		8.5	10	8	8	10	8	10	10.0		10	**89**
108	4	28.9		10.0	0	10	10	7	9		7.5	9.3	0	**74**
110	10	30.0		10.0	10	10	10	10	10	10	10.0	10.0	10	**100**
112	10	21.0		10.0	10	5	8	8	4	10	10.0	6.7	10	**80**
120	9	27.0		8.5		10	8	10	10	10	10.0	10.0	8	**93**
124	10	27.5		10.0		10	10	6	9	10	10.0	10.0	8	**93**
157	8	28.4		7.0	10	10	10	8	9	8	5.0		9	**86**
164	10	29.7		5.0	4	10	10	10	10	10	10.0		10	**91**
172	10	22.1		6.0	9	10	10	10	9	10	7.5	9.0	10	**88**
188	10	29.5	10	10.0	9	10	10	10	9	10	10.0	8.0	10	**97**
199	10	27.8		10.0		10	10	10	10	10	10.0	7.7	10	**97**
205	9	25.9		10.0		9	5	9	10	7	10.0	10.0	9	**88**
216	10	30.0		7.5	9	10	10	10	10	10	10.0	10.0	10	**98**
217	10	27.0		8.5	8	10	10	7	10		6.0		10	**89**
245	5	23.7		10.0		7	7	10	10	10	6.0	10.0	4	**79**
257	10	23.5		7.5	10	5	10	10	10	10	3.0	7.0	10	**83**
260	10	26.5		8.5	9	9	0	4	0	10	7.5	10.0	8	**73**
263	10	28.6		6.0	9	10	10	10	5	9	10.0	10.0	6	**88**
285	10	21.0		10.0	7	10	8	10	8	10	10.0	10.0	10	**89**
293	8	28.1		9.0	10	10	10	9	10	10	10.0	7.0	10	**94**
295	10	29.5		9.0	10	10	10	10	10	10	9.0	10.0	8	**97**

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-603 LAA	LS-604 BRD/ABS (CA)	LS-606 $MgSO_4$ (CA)	LS-607 % Crush	LS-621 % Asphalt	LS-608 % Flat & Elongated	LS-618 MDA (CA)	LS-614 F/T	LS-605 BRD/ABS (FA)	LS-623 One-Point Proctor	LS-619 MDA (FA)	Rating
296	10	29.5		9.5	9	10	10	10	10	10	10.0	5.3	10	**95**
301	9	27.5		9.5	10	9	10	6	10	10	10.0	10.0	10	**94**
309	4	25.4		8.5	10	10	10	1	10	10	6.0	10.0	10	**82**
312	8	24.8		8.5	10	5	10	9	9	10	9.0	4.7	5	**81**
316	10	30.0		8.5	10	10	10	10	10	10	10.0	10.0	8	**98**
321	10	25.9		8.0		10	10	10	8	10	10.0		10	**93**
326	10	25.9		0.0		10	10	9	9	9	8.0	9.7	10	**85**
340	10	24.5		10.0		10	10	10	8	10	5.5		10	**90**

Appendix E3: Soil Laboratory Ratings

Lab No.	LS-702 Hydrometer Analysis	LS-703 & 4 Atterberg Limits	LS-705 Specific Gravity	Rating
8	8.0	10.0	10	93
9	8.8	10.0	10	96
12	9.0	9.3	10	94
13	8.6	9.3	0	60
15	8.0	8.3	10	88
18	9.6	8.7	10	94
19	9.6	10.0	4	79
20	8.4	9.3	9	89
21	9.6	9.0	7	85
22	9.4	9.7	10	97
23	9.0	7.7	0	56
27	9.8	9.3	9	94
28	9.6	10.0	10	99
29	9.0	5.3	10	81
30	9.4	10.0	7	88
31	9.6	5.3	7	73
32	8.0	8.7	10	89
35	9.6	9.3	10	96
37	9.6	10.0	10	99
38	9.8	9.7	8	92
44	9.8	8.0	10	93
46	8.0	8.3	10	88
47	3.8	10.0	10	79
52	8.0	5.7	0	46
54	8.0	9.7	9	89
56	6.2	10.0	0	54
58	9.2	10.0	10	97
59	10.0	10.0	10	100
62	8.4	10.0	8	88
63	8.8	10.0	8	89
64	9.6	7.0	8	82
68	8.6	9.7	10	94
69	8.2	7.0	10	84
71	8.8	10.0	9	93
72	9.6	10.0	10	99
79	9.8	10.0	7	89
80	9.2	7.7	8	83
83	9.6	0.0	7	55

Lab No.	LS-702 Hydrometer Analysis	LS-703 & 4 Atterberg Limits	LS-705 Specific Gravity	Rating
86	9.6	10.0	9	95
94	8.2	7.3	8	78
98	0.2	9.0	0	31
101	9.4	7.7	10	90
102	9.0	8.7	10	92
112	9.8	6.0	5	69
120	10.0	9.0	10	97
138	9.6	10.0	10	99
139	9.6	3.7	6	64
146	10.0	10.0	9	97
172	2.6	9.3	10	73
188	9.6	8.3	10	93
208	9.6	10.0	10	99
210	9.2	10.0	10	97
216	9.6	10.0	10	99
260	9.6	10.0	0	65
276	9.6	10.0	9	95
284	8.0	7.0	9	80
285	10.0	9.0	7	87
287	9.4	9.7	2	70
295	9.6	10.0	4	79
296	9.2	9.3	6	82
299	9.0	9.7	10	96
300	6.6	9.7	10	88
301	9.8	10.0	10	99
312	10.0	9.3	10	98
315	7.6	2.0	0	32
320	9.4	10.0	9	95
326	7.8	7.3	10	84

Appendix E4: Superpave Laboratory Ratings

Laboratory No.	C1252/T 304 Uncompacted Void Content	D2419/T 176 Sand Equivalent	ASTM D5821 % Fractured Particles	ASTM D4719 % Flat & Elongated	Rating
12	9	10	9	10	**95**
13	10	7	10	10	**93**
15	10	10	10	9	**98**
18	10	10	10	10	**100**
19	10	6	10	10	**90**
20	9	8	10	9	**90**
21	8	6	10	9	**83**
22	10	8	10	10	**95**
25	10	10	10	8	**95**
26	9	10	10	9	**95**
27	10	10	7	8	**88**
28	10	10	10	7	**93**
31	9	9	10	10	**95**
32	5	10	9	10	**85**
33	8	10	9	8	**88**
35	10	10	9	10	**98**
37	10	9	10	9	**95**
39	5	6	10	5	**65**
43	10	9	9	10	**95**
47	10	7	8	9	**85**
56	6	7	10	0	**58**
58	10	10	10	10	**100**
59	10	8	10	9	**93**
61	5	10	10	10	**88**
62	10	10	10	10	**100**
69	9	10	8	10	**93**
71	4	9	10	10	**83**
75	10	10	9	8	**93**
77	2	9	4	10	**63**
79	10	9	7	10	**90**
80	10	10	1	9	**75**
86	10	2	10	10	**80**
101	10	10	9	7	**90**
112	8	8	3	8	**68**
115	9	6	5	4	**60**
120	10	10	10	10	**100**

Laboratory No.	C1252/T 304 Uncompacted Void Content	D2419/T 176 Sand Equivalent	ASTM D5821 % Fractured Particles	ASTM D4719 % Flat & Elongated	Rating
124	6	8	9	10	**83**
157	10	7	10	10	**93**
172	9	10	10	9	**95**
180	10	10	9	10	**98**
181	10	9	9	10	**95**
182	5	8	9	7	**73**
188	10	10	10	10	**100**
193	10	10	10	6	**90**
199	9	10	10	2	**78**
215	3	0	10	8	**53**
216	10	8	10	10	**95**
217	8	10	10	8	**90**
236	9	0	5	10	**60**
245	7	10	9	8	**85**
255	10	9	10	8	**93**
257	4	9	2	0	**38**
263	9	10	6	10	**88**
271	10	10	9	10	**98**
272	10	10	10	10	**100**
285	10	10	6	8	**85**
293	9	10	10	9	**95**
294	10	10	10	10	**100**
295	9	9	10	8	**90**
296	10	10	10	9	**98**
300	0	10	9	5	**60**
312	10	8	5	3	**65**
316	8	10	10	10	**95**
326	9	10	10	10	**98**
327	10	10	8	7	**88**
328	10	10	10	10	**100**
340	9	7	10	6	**80**